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GEOLOGICAL SURVEY

—OF—

ALABAMA,

EUGENE ALLEN SMITH, State Geologist.

REPORT

ON THE

GEOLOGY OF THE

COASTAL PLAIN OF ALABAMA.

(CRETACEOUS, TERTIARY, AND POST-TERTIARY FORMATIONS.)

WITH ILLUSTRATIONS.

MONTGOMERY, ALA.
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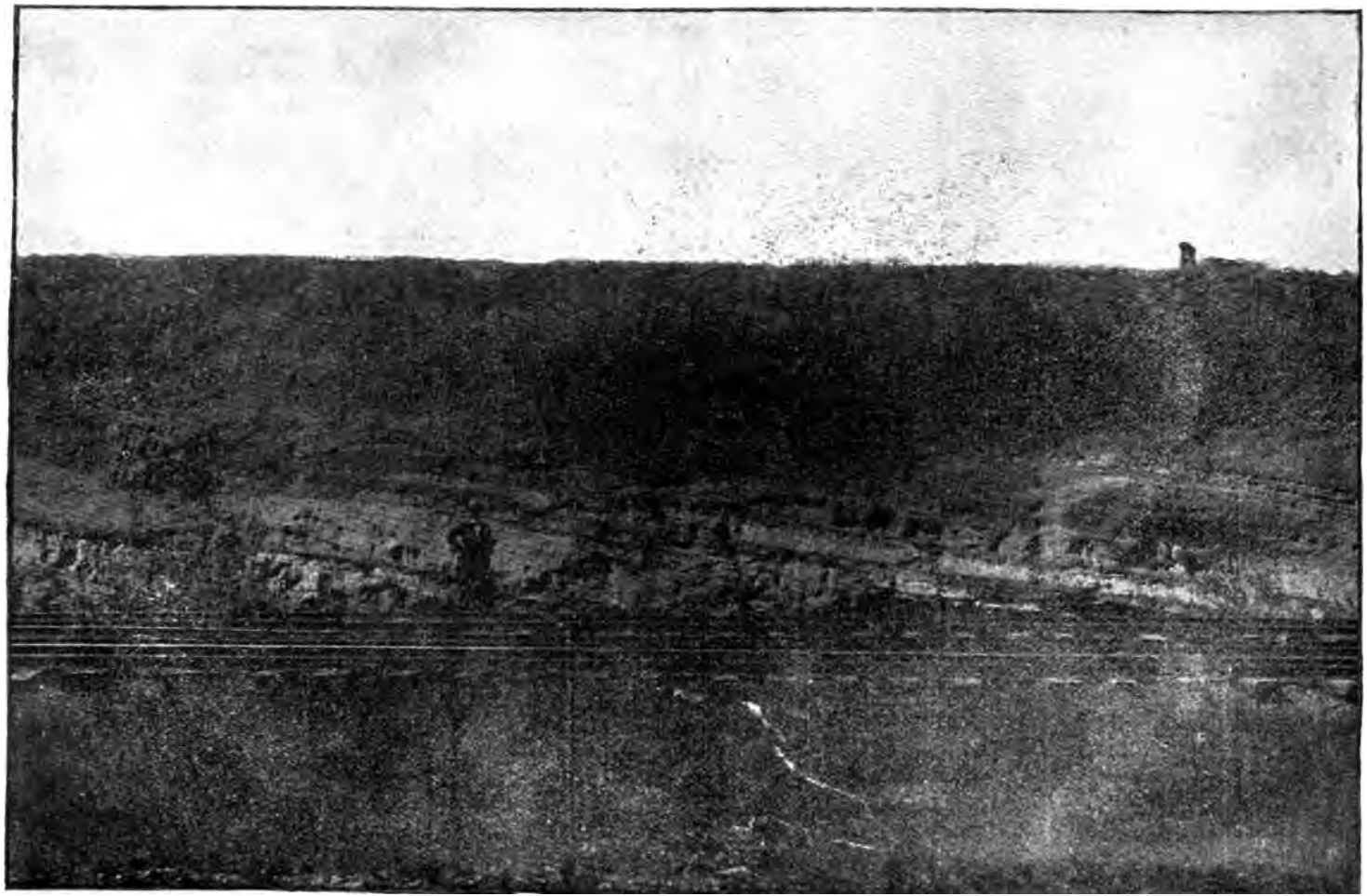

GEOLOGICAL SURVEY

—OF—

ALABAMA,

EUGENE ALLEN SMITH, Ph.D., State Geologist.

REPORT

ON THE

GEOLOGY OF THE

COASTAL PLAIN OF ALABAMA,

BY

Eugene A. Smith, Lawrence C. Johnson, and Daniel W. Langdon, Jr.,

WITH

CONTRIBUTIONS TO ITS

PALEONTOLOGY,

BY

T. H. ALDRICH AND K. M. CUNNINGHAM.

WITH ILLUSTRATIONS.

MONTGOMERY, ALA.:
THE BROWN PRINTING CO., STATE PRINTERS AND BINDERS.
1894.

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To His Excellency,

Governor THOMAS G. JONES:

DEAR SIR—With this I transmit my Report upon the Geology of the Coastal Plain of Alabama.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

UNIVERSITY OF ALABAMA, July 1, 1894.

PREFACE.

That part of our Coastal Plain traversed by the great central river system of Alabama, has long been known to geologists on account of the fine exposures of the strata along the river banks, and the great number and perfect state of preservation of the fossil shells of some of the horizons. The best known of these localities is Claiborne, on the Alabama River, from which place specimens have been sent to all the principal museums of the world.

The completeness of the series of Eocene and Cretaceous strata exposed along this river system was not fully appreciated until 1872, when the present writer collected at Wood's Bluff, on the Tombigbee River, a large number of shells, many of which were new to science, and demonstrated the fact that below the Buhrstone, which up to that time was considered the base of the Tertiary formation, there existed in Alabama a great series of strata of Tertiary age, equal in thickness to the super-Buhrstone series. Evidence was also then collected of the fact that these lower Tertiary strata, equivalent to the Great Lignitic of Dr. Hilgard in Mississippi, held interstratified with the generally barren sands, beds of marine shells, in striking contrast to the Mississippi Lignitic strata in which fossils other than those of vegetable origin are comparatively rare.

In taking up the study of the formations of the Coastal Plain of Alabama, attention was naturally first turned to this part of it, the river banks holding out greatest promise of sections from which a complete stratigraphical column might be constructed. How well this promise has been fulfilled may be seen in the following pages, which show that we have in this section of Alabama the most complete and

varied series of Eocene and Cretaceous strata known in the United States.

The first systematic attempt at the stratigraphy of the Cretaceous and Tertiary of the Gulf region of Alabama, began in the summer of 1883, when Mr. L. C. Johnson, of the United States Geological Survey, and myself, made an excursion of two weeks in a small steamer from Tuscaloosa down the Tuscaloosa or Black Warrior River, to its confluence with the Tombigbee, down the latter stream to its confluence with the Alabama, down the Alabama to the head of Mobile Bay, and thence up the latter river to Prairie Bluff. The cost of this trip was borne jointly by the United States Survey and the State Survey, and it was proposed by Major J. W. Powell, Director of the United States Geological Survey, to publish the results obtained as a Bulletin of his Survey, to be fully illustrated by map, sections and views, the use of which could be secured to the Alabama Survey without further cost except for the electrotyping of the cuts, a merely nominal sum. Accordingly I devoted most of my time until the summer of 1885, to the writing up of this report, and sent in to Major Powell the manuscript of the first draft of it in July, 1885. During the latter part of this summer, however, in company with Mr. T. H. Aldrich and Mr. D. W. Langdon, Jr., of the Alabama Survey, I went again over a good part of the same ground, as well as over other territory not examined by Mr. Johnson and myself, and collected additional matter which made necessary so many changes in the report as first written, that it was recalled and has since been entirely recast. During this summer also many photographs were made by me of the exposures of strata referred to in this report, and twelve of these have been engraved to illustrate the Bulletin of the United States Geological Survey, and they appear also in this document.

The season of 1886 was also devoted to the study of the same regions by Mr. Langdon and myself, and the results then obtained were likewise incorporated in Bulletin No. 43*

*On the Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee and Alabama Rivers.—Washington, 1887.

above referred to, which constitutes the nucleus of the present report, and which gives a measurably complete stratigraphical column of these formations as exposed along the Alabama, Tombigbee and Warrior Rivers. The exposures along this great river system, being far more complete than elsewhere, have been taken as the types to which the sections in the other parts of the State are referred.

Away from these rivers, however, and especially as we come eastward, we find very material variation both in the thickness and in the component materials of these formations, and to Mr. Langdon was assigned the task of ascertaining and reporting upon these variations in the region between the Alabama and Chattahoochee Rivers. In performance of this task, during the summers of 1887–'88 and '89 he made careful examinations of the banks of Conecuh, Pea and Chattahoochee Rivers, and of the intervening territory, and his results appear in this report in full, for the first time, though a summary of them was presented by him to the Geological Society of America, and printed as one of its Bulletins.*

During the years 1890–91 Mr. Johnson, in part under the auspices of the United States Geological Survey, and partly for the Alabama Survey, spent much time in field work in the lower part of the State, and made some important contributions to our knowledge of the later Tertiary and Post Tertiary formations there. His work has definitely fixed the horizon of the *Grand Gulf* formation, and has added a new division to the Miocene formations of the Gulf coast, viz.: the *Pascagoula*, and has contributed no little to the accurate determination of the equivalencies of the Pleistocene or Post Tertiary formations of the same region.

This sketch will explain the form and arrangement of the present Report, in which, in the first section of Part I, all that relates to the Eocene and Cretaceous formations of the vicinity of the Alabama and Tombigbee rivers, is substan-

*Bulletin of the Geological Society of America. Vol. 2, pp. 587-606, 1891.

tially a republication of Bulletin 43, above named, with some slight changes and additions. The most important of these additions are the several articles of Mr. Cunningham upon the microscopic forms occurring in our Cretaceous and Tertiary formations, and the paper by Mr. T. H. Aldrich upon the paleontology of the Clayton or lowermost Tertiary. This paper, together with the four plates illustrating it, Mr. Aldrich contributes free of all cost to the survey.

The accounts of the later Tertiary, (Miocene) and post Tertiary formations are also new, and appear in this report for the first time.

In the second section of Part I, follows Mr. Langdon's description of the variations of the Eocene and Cretaceous formations in the territory between the Alabama and Chattahoochee rivers, together with an account of his discoveries of the Marine Miocene formations at Chattahoochee and Alum Bluff in Florida.

In Part II, I have brought together all the data which seem to me likely to be of practical value concerning the various phosphatic marls, greensands, etc., occurring in this part of the State. This matter has already been printed in small edition as Bulletin No. 2 of the State Survey. As thus originally printed in independent form certain geological details and descriptions were indispensable, and in the present report, for convenience of reference, these details have been retained, notwithstanding the small amount of repetition involved.

In Part III, I have placed a number of geological and other details, which could not conveniently find place in the general description but which were thought to have something of more than local interest. In this presentation by counties, some repetition is unavoidable, but, I think, justified by the great convenience arising from the geographical arrangement of the material.

In Bulletin No. 43 appeared some valuable notes on the bibliography of the lower Cretaceous formations, and upon the genesis of the various formations of the Alabama Coas-

tal Plain from the pen of Mr. W. J. McGee, of the U. S. Survey. We have used these notes freely in this report and express herewith our indebtedness therefor.

The survey has received from year to year from the authorities of the various railroads traversing the Coastal Plain, many courtesies which are here thankfully acknowledged.

To individuals in various parts of the state, our obligations for civilities extended are numerous and weighty, so numerous indeed, that it is impossible to enumerate them. For all these we feel and express our sincere thanks.

EUGENE A. SMITH,

University of Alabama, July 1, 1894.

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PART I.

ON THE GEOLOGY OF THE COASTAL PLAIN OF ALABAMA: CRETACEOUS, TERTIARY, AND POST-TERTIARY FORMATIONS.

—BY—

Eugene A. Smith, Daniel W. Langdon, Jr., and Lawrence C. Johnson.

INTRODUCTION.

I. General Principles.

Among those into whose hands this book may come, it may safely be assumed that there will be many who will be interested in the questions as to the origin of the strata which compose the terrane of which we are writing; i. e. from what were the materials derived with which its strata are built up; by what processes were they accumulated; and under what conditions have they come to be just what we now find them to be; to what do they tend in the future? It is the business of the geology of the present day to satisfy as far as possible such reasonable demands of intelligent readers, and with this object in view a brief presentation of some of the most important of the geological first principles and their application in interpreting the history of the development of Alabama, may well precede the main body of the present Report.

While it is in the highest degree probable that the "primitive rock," or that which first formed on the earth's surface by the gradual cooling of the "molten globe," nowhere at this time remains exposed to view in its original position and condition, yet in all parts of the world the most ancient rocks, in their crystalline texture, mineral composition, and general structure, approach very closely to what according to all analogy, this primitive rock must have been. From such ancient crystalline rocks as these, we may reasonably conclude, all the latter rocks have been formed by processes that are active at the present time, and probably have been from the beginning. If we consider these agencies somewhat closely, we shall, I think, find a rational explanation in a great measure of the structure and distribution of the rocks that make up that particular part of the earth's crust with which we in Alabama are most deeply concerned, and of the quality of the materials of which they are composed.

Upon exposure to the action of the frost, the moisture, the oxygen and carbonic acid of the atmosphere, the ancient crystalline rocks above referred to, would gradually be broken down mechanically into fragments of greater or less size, and changed in composition by chemical action, the more soluble portions being leached out, leaving the less soluble as a residual mass. And since most crystalline rocks are made up of the minerals *quartz*, *feldspar*, *mica* and *hornblende*, in other words of silica and its compounds with alumina, iron, lime, and alkalies, the end result of these processes of disintegration and decay would be the formation of a more or less impure clay, mixed with sand (fragments of quartz), scales of mica, and fragments of more insoluble and not easily disintegrated minerals. This mixture with the addition of organic matter constitutes what we commonly designate as soil.

It is evident that upon any sloping surface only a portion of the loose matters resulting from the disintegration of rocks will remain as soil; the rest will be carried down by brooks, rivulets, and rivers into the sea. The coarser particles that have not been dropped on the way, will be deposited upon reaching the still waters of the ocean, close to the shore, while the finer materials will remain longer in suspension and be distributed far and wide over the sea bottom, but still at no very great distance from the shores. The other materials which have been taken into solution and reach the shore in this form, can be precipitated out of the dissolving water only by means of some chemical reaction, or else through the agency of some kind of organism.

From this we see that beds thus accumulated will consist of materials more or less completely sorted by the action of water, and in this differentiation of the materials, these newly formed beds are in most striking contrast to the original rock.

The constant grinding and rubbing together of the fragments of rock on their way to the sea, and after reaching the sea also under the action of the waves, result in the breaking off of corners and angles and the rounding up of

the fragments into bowlders and pebbles, and the formation of sand and still finer mud.

By reason of successive changes along the coasts, especially in the depth of the water, as a result of oscillations of the crust, these various sediments may succeed each other in every order, sands upon muds, pebbles upon sands, sands upon pebbles, but in all cases we can understand how the coarser sediments must have been accumulated nearer the shore or in shallow water, while the finer matters would be borne out and deposited in the deeper and stiller waters beyond, or else in sheltered places of still water near the shore.

The sediments which in any of the ways above described are deposited upon the sea bottom, are in many cases in process of time converted into rocks by pressure or by the accession of some kind of cement which binds the particles together, although the degree of coherence does not enter essentially into the definition of a rock.

The fragmental rocks thus formed are called conglomerates, grits, sandstones, or shales according to the size of the constituent particles, and these make up a great proportion of the secondary or derivative rocks of the earth's surface.

There remains yet one great class of rocks to be accounted for, namely the limestones. Rocks of this class now in course of formation, are seen to be almost wholly of organic origin, and to be the result of the activity of the coral polyp and of still lower forms of the animal kingdom. In any text book of geology may be found the explanation of the formation of beds of calcareous matters from the ground up and comminuted fragments of shells, corals, etc., and we may take it for demonstrated that all our great beds of limestone have been formed in this way, and have been accumulated upon the floor of moderately deep and clear seas. Where these beds of pure calcareous matters, including chalky deposits, have been mingled at intervals with muds and other sediments, the resulting limestone is more or less impure, and of the nature for instance of our rotten limestone

or prairie formation. Where a large proportion of silica, derived from the silicious spicules of sponges, and from the tests of shells of certain other low forms of animal life, is mingled with the calcareous matter, we have flinty or silicious limestones, such as are found in the Subcarboniferous and Silurian formations of our State.

By secular movements of the earth's crust, these newly formed rocks may be lifted above the sea and added to the dry land, retaining in their structure the marks of their origin as sediments accumulated under water.

We have, therefore, only to consider the conditions which at the present time determine the character of the accumulation of sediments along our coasts, in our rivers and estuaries, and in the depths of the seas beyond, in order to have some clear idea of the conditions under which the materials have accumulated which form the stratified or sedimentary rocks of the several formations which make the substratum of our own State, or of any of the United States, or of the world. We have no reason for thinking that sedimentary or stratified rocks have ever been formed in any other way than that which we now see in progress before our eyes.

As the dead bodies of animals, and the leaves and other remains of plants are now being imbedded in the muds and sands and thus preserved from decay, or at least preserved in casts or moulds or impressions when the original organic matter has been removed by decay or otherwise, so it has been in all past times with the bodies of the animals then living and with the leaves and parts of contemporaneous plants; and since the sea or its estuaries and great bodies of fresh water have been the accumulating ground for the sediments, so the great majority of the fossil forms are of marine or aquatic species, the main exception being found in those accumulations of vegetable matter that constitute our beds of coal, peat and lignite. No one at the present time, I believe, considers the fossils found in rocks as freaks of nature or as puzzles, but all alike unite in the belief that they are the impressions or remains of organisms formerly living upon the earth. By a study of these forms

we may get a clear and definite idea of the gradual development of the organic world. And no one, I imagine, can fail to see the wide differences in form and general aspect of the earlier animal plants and of the modern types, and the gradual approach to these modern types as we ascend the geological scale. Whether these changes have been produced by the operation of natural laws now and always heretofore in force, or in some other way, we need not here discuss, we are only concerned with the *fact* which is patent to any one who will take the trouble to examine for himself. We acknowledge and work upon this fact when we make use of shells and other organic, remains to identify and distinguish geological formations.

The sediments laid down on the bottom of the sea or of lakes are of course originally in approximately horizontal sheets, or beds, but as a matter of fact we often see the rocks exhibiting very wide departures from this their original position; lying titled at varying angles, even to verticality, bent into folds and wrinkles, and these still further complicated by the removal by erosion of parts of the folds.

All these phenomena show that the sediments while or after being lifted up above the sea level, have been subjected to some force which has thrown them into a series of wrinkles and folds and lapped these folds closely together, some times breaking them apart and sliding the one half bodily over the other, and long continued study of these phenomena has brought geologists to the conclusion that these foldings have a close relation and causal connection with the shrinking of the mass of the earth : but we need not go further into this subject.

Whether uplifted without disturbing their original horizontal position, or whether thrown into wrinkles and folds, these sediments when brought above the sea level are at once subjected to the action of frost, rain, and decay, and are broken down by mechanical and chemical means in the manner above described and are worked into soils, or washed down and carried eventually into the sea where they again accumulate in sediments, that may again be consolidated

into rocks that may again be raised above the sea, again subjected to disintegrating and transporting forces, and so on indefinitely.

In this process of degradation the softer beds are more easily worn away than the harder ones, and thus arise those inequalities of the surface which constitute the hills and and valleys, and when great elevation has preceded the erosion, the highlands may become mountains.

Applying these general principles we discover that all the materials constituting the rocks of Alabama, excepting possibly some of the crystalline rocks, are of sedimentary origin, i. e. they have been accumulated under water in the manner above described, they are all arranged in beds or layers, or *strata*, to use the technical term.

And a further examination into the structure and distribution of these stratified rocks, leads us to certain well grounded conclusions as to the conditions under which they were accumulated, and enables us to follow with an approach to certainty the various stages in the development to its present condition of this particular part of the earth's crust.

In the following pages, before proceeding to the detailed descriptions which make the body of this report, we shall endeavor briefly to sketch the history of this development as recorded in the materials and structure of the rocks, to point out the two great divisions into which the strata naturally fall, and to give such minor details of topographic and geological features of these two divisions as may thought necessary to the full appreciation of the descriptions which follow.

II. Application of these Principles in Interpreting the Geological History of Alabama.

Two-fold Division of the State, based upon the Genesis of the Constituent Strata.

As regards its topographical and geological features, Alabama may be divided into two sharply defined provinces:

the northeastern two-fifths, characterized by more or less mountainous topography, consolidation of the generally corrugated roak strata which compose it, and the ancient aspect of the fossils contained in these strata. From the last named character this section has been called the *Paleozoic* (ancient life) terrane, and from the fact that most of the economically important minerals of the State occur here it has more popularly been designated as the *Mineral Region.*

The southwestern three-fifths, with the general characters of a plain sloping gently seaward, with few elevations above 500 feet, and these produced solely by erosion, built up of loosely consolidated beds of sand and clays in nearly horizontal position except a slight seaward dip of 30 to 40 feet to the mile, and holding fossils of more modern aspect, hence named the *Mesozoic* (middle life) and *Neozoic* (modern life) terrane, constitutes the Coastal Plain, popularly designated the *Agricultural Region.*

THE MINERAL REGION.—These two areas are also widely different as regards the origin of the rocky strata of which they are composed. The mineral region shows in the geographical distribution of the constituent strata and their varying thickness, that these strata, or at least the oldest of them, have been derived from the waste of a land area which lay to the *east* of the present limits of this division, extending probably over a part of the area now covered by the waters of the Atlantic Ocean, and that this waste was carried down and spread upon the floor of an interior sea which covered most of the great Valley of the Mississippi. This interior sea was at times deep enough to sustain corals and other limestone forming animals, at other times shallow enough to permit of the accumulation of sands over the greater part of the sea bottom, and at times it was well nigh obliterated and was converted into a marsh supporting the growths which afterwards became coal. In most of the formations of this division we can easily see that the greatest thickness of sediments and the coarsest materials are to be found furthest to the east, and thus presumably

nearest to the original land mass from which they were derived.

The waste from this land mass as we have said, was carried down northwestward and spread upon the floor of the interior sea. Whatever may have been the oscillations of this sea bottom during the progress of accumulation of the sediments that compose the Paleozoic formations, the whole area became permanently dry land only after the close of the Carboniferous period, when the former sea floor was elevated and corrugated into numerous wrinkles, stronger and more pronounced to the eastward and gradually dying out towards the west and northwest. With the addition of this area to the dry land of the continent the *first period* in the evolution that part of the continent embraced within the limits of the state was accomplished, the Mineral Region came into existence as land, and from the disintegration of its rocks came the materials for future geological formations.

This section of the state falls naturally into the following minor divisions:

a. The Piedmont Plateau.—In this section the rocks are as far as possible different from the condition of ordinary sediments of sand, mud, &c.; they are *crystalline* or made up of distinct individuals of quartz, feldspar, mica, etc., usually disposed in sheets or layers the origin of which has received different interpretations.

b. The Valley Region.—To the northwest of the Piedmont region and extending as far as the Valley in which Blount Springs is situated, we find an area in which the strata have been more or less uplifted, folded and otherwise disturbed, with the intensity of the folding gradually decreasing northwestwards. This whole region is characterized topographically by alternations of ridges and valleys, all having a general northeast and southwest direction, and all built up of the conglomerates, sand-stones, shales, cherts, and limestones of the older geological formations, Cambrian, Silurian, Devonian, and Carboniferous as they have been called.

c. *The Cumberland Plateau and other Coal Fields.*—In the strips separating the valleys above named and in the great region lying to the westward and northwestward of them as far as the borders of the Great Valley of the Tennessee, we find at the surface, that formation which helps materially to make Alabama one of the first states of the Union, viz: the Coal Measures.

d. *The Valley of the Tennessee.*—To the north and northwest of the Columberland region as above outlined, lies the great valley of the Tennessee, floored with the limestones and cherts of the Subcarboniferous formation, with its strata nearly horizontal, but with slight southerly dips.

Bordered on the south by the escarpments of the Cumberland table lands, this division merges towards the northwest, in its topography and geology, into the great basin of the Mississippi. In its eastern portion it interlocks with the flat topped knobs and mountains of the Cumberland, while towards the west it slopes off into the Coastal Plain.

These formations with the topographic and geological features above outlined constitute our Paleozoic or Ancient terrane, the nucleus of our land area.

THE AGRICULTURAL REGION; COASTAL PLAIN.—With the addition of this the *Mineral* region to our permanent land there was instituted a new order of things: the washings from the new land mass were no longer as heretofore carried down towards the *northwest* to be spread upon the floor of the interior sea, since that had been obliterated, but the drainage from this time on was *eastward* into the Atlantic and *southward* and *southwestward* into the great Mississippian Bay which then washed the shores of the new born continent as far north as the mouth of the Ohio river.

During the time when the sediments which constitute the Triassic and Jurassic formations were accumulating in other parts of North America, that part of the continent which was embraced within the present limits of this state stood probably much higher above tide level than it did subsequently at the beginning of the Cretaceous period, and prob-

ably its elevation was greater then than it now is, and the shore line of the Gulf further southward than its present position, for none of the sediments which must have been accumulated from the waste of our Alabama terranes during this period, have ever been subsequently exposed to view.

They were probably deposited far out into the Gulf, and lie now hidden below great thickness of later deposits, and probably also in part below the waters of the Gulf.

After the time known by Geologists as Jurassic, however, there was a lowering of the land sufficient to bring the greater part of this elevated region below sea level, so that the coast line of the great Mississippian Bay extended across Alabama approximately along a line connection Florence, Woodstock, Blocton, Clanton, Wetumpka, and Columbus, Georgia.

The disintegration by atmospheric agencies of the Paleozoic land mass of the Mineral region then furnished material which was carried down by the rains, rivulets and spread upon the floor of the great Bay in the form of pebbles and coarse sand near the shore and in shallow places, and in the form of fine sands and clay in the deeper parts further from the shores, while in still deeper waters not reached, or only partially affected by the washings from the land, flourished the corals and other marine animals that formed the limestone. In this way were accumulated the strata of the Cretaceous and Tertiary, and part of the later formations.

During all the time from the beginning of the Cretaceous to the end of the Tertiary, there was a gradual elevation of the land and sea-floor (varied at intervals by periods of rest and even downward movement). The result of this movement was to transfer towards the south and west the shore line of the Gulf, and to add to the dry land in successive belts, the sediments which had accumulated along the coasts. As each belt of these deposits was added to the land, it in turn was subjected to erosion and contributed its share to the materials carried down by streams and deposited upon the bottom of the sea to form the strata of the newer for-

mations, themselves in time and in similar way to be added to the firm land.

From this their mode of origin it will be seen that our Cretaceous and Tertiary formations consist of strata having a gentle slope towards the Gulf, and coming to the surface in approximately parallel belts across the state, the oldest of these beds furthest towards the north, the newer beds occupying the surface one after the other as we go southward in the order of their relative ages.

These newly formed terranes constitute the greater part of the Coastal Plain and with their elevation terminated the *second period* in the geological evolution of Alabama.

Before going on to the consideration of the next period, it may be well, since the present report is to deal especially with these formations, to trace out in more detail the steps by which these Cretaceous and Tertiary beds were gradually built up.

By making careful measurements of the exposures along the banks of streams and gullies, and from the records of deep borings, the aggregate thickness of these formations has been found to be some 5,500 feet, and of this, 2,500 feet may be referred to the Cretaceous, 1,800 to the Eocene, and the rest to the later Tertiary and Quaternary.*

By far the greater part of these sediments are shallow water deposits, consisting of sands and clays in many alternations. From the study of the nature and succession of these constituent strata, the gradual development of our Coastal Plain in its essential features at least, may be outlined as follows:†

*These figures, as regards the Cretaceous and Eocene are probably nearly correct, but those for the later Tertiary and Quaternary are estimates.

†The first attempt at a statement of the probable physical conditions attendant upon the accumulation of the Eocene and Cretaceous deposits of the Alabama Coastal plain was given by Mr. McGee as a chapter in Bulletin 43 above referred to. We acknowledge our indebtedness to him in all that follows concerning the genesis of these formations.

a. Cretaceous.—At the beginning of the Cretaceous period, the shore line of the Mississippian Bay, lapped well up on the present Paleozoic area, and stretched in an irregular curve from near Columbus, Georgia, westward by Tallassee, to Wetumpka, and thence northwestward by Verbena, Clanton, Montevallo, Blocton, and thence in more northerly direction approximately along what is called the Byler Ridge, to the escarpment overlooking the Tennessee Valley. Across the Valley the border of the Cretaceous seems to lie a little further eastward.

The first deposited sediments in this great sea, 1,000 to 1,500 feet in thickness, are shore deposits of sands and pebbles, with thin partings of clay in places, and at several horizons thick masses of clays now usually of reddish to purplish colors. Some of these clay masses are laminated and contain beautifully preserved impressions of leaves from which the geological age of the deposits has been placed beyond doubt.

These beds have received names from the localities where they are best displayed, viz: *Tuscaloosa* and *Eutaw*. During the first part of this period it is probable that the sea bottom was slowly subsiding in proportion as it was silted up by the washings from the land, and that the muddy fresh waters from the land were inimical to animal life along these coasts. Logs and leaves, however, were carried down and became imbedded in the clays and sands and we now see them in the form of leaf impressions, lignitized trunks, and beds of lignitic matter. With continued deposition a submarine terrace analogous to those now fringing the Atlantic and Gulf coasts was apparently developed; and, with the growth of the terrace and consequent shallowing of the off-shore waters, there was evidently a diminution in strength of currents and violence of waves accompanied by a diminution in the variety and coarseness of sediments.

Towards the end of this period and succeeding that of the deposition of what we have called the Tuscaloosa formation, there occurred a diminution in the rate or perhaps a cessation, of the downward continental movement; but

there were continued growth of the submarine terrace, shoaling of the sea by reason of sedimentation, and some recession of the shore line. In places and especially near the end of the period animal life became possible, as is witnessed by the shell beds which characterize the uppermost beds of the Eutaw everywhere, and some of its lower beds in the central and eastern parts of the state. These uppermost fossiliferous beds mark the transition from the shallow water and littoral deposits of the Eutaw and Tombigbee sands, to the great limestone and chalk formation of the Cretaceous next to be considered.

The Rotten Limestone or *Chalk* epoch was marked by a comparatively sudden renewal of the continental depression and a rapid deepening of the sea. In the deep waters of this period the fossiliferous limestones, chalks, and marls of the Cretaceous were laid down. During this epoch it is probable that the shore line in places lapped up well on the older or paleozoic terranes and even beyond the Tuscaloosa shore line. From the distribution of the various deposits of this later Cretaceous era, we may infer that the great deepening of the sea was rather local than general, its maximum being about Livingston and the parts of Mississippi next adjoining, for both to the east and to the northwest of this region the proportion of the chalk or open sea accumulations diminishes, failing altogether in eastern Alabama and adjoining area in Georgia, on the one hand, and in northern Tennessee on the other. At these two extremities of the Gulf Cretaceous east of the Mississippi river, the conditions characterizing the close of the Eutaw epoch as above sketched, appear to have remained unchanged from the Eutaw time to the end of the Cretaceous, and the whole series of strata there consists of sands, clays and marl beds, i. e. shell deposits. In the central or typical portion of our Cretaceous area however, from the meridian of Montgomery, westward, the closing episode of the Cretaceous was marked by a reversal of terrestrial movements, a retreat of the shore line down the submarine terrace above mentioned, and a diminution in the abundance of marine life, especially of

open, clear sea forms, and a corresponding increase in the proportion of off-shore or littoral deposits. These deposits constitute the *Ripley* type of the later Cretaceous.

b. Tertiary.—The Tertiary was introduced by an arrest of the Ripley elevation, a rapid deepening of the sea and retreat inland of the shore line, especially in eastern Alabama and adjoining parts of Georgia, as evidenced by the formation of the calcareous deposits of the *Clayton* or *Midway*, thicker or more calcareous in the east, and diminishing in volume and becoming more argillaceous towards the west, in exact contradistinction in local distribution to the open sea deposits of the Rotten Limestone.

There is thus a paleontologic but not, in the portions that have resisted erosion, a physical break in the sequence of events and in the continuity of strata.

The next division of Tertiary, the *Lignitic* was characterized by a shoaling of the waters of the Clayton seas, over the submarine terrace, a refreshening of these waters near the shores and a consequent destruction of marine organisms, and an extension of the land flora and a commingling of its remains with the littoral deposits. The altitude of the land with respect to the sea was generally persistent throughout the Lignitic epoch but depression went on apparently *pari passu* with sedimentation, and there were occasional oscillations and consequent incursions of the sea upon the land—notably those represented by the Wood's Bluff and *Gryphæa thirsæ* beds—and excursions of the terrestrial flora upon the coastal marshes.

The Lignitic formation is the analogue of the Tuscaloosa; but by reason of the less acclivity and the less inequality of the sea bottom and the greater regularity of the shores the waves and currents were less violent, and in consequence the deposits are more homogeneous. The approximate horizontality and the shallowness of the sea bottom are attested by the great geographic extent of beds referable to slight changes in depth of the littoral waters.

From the initiation of the Tuscaloosa epoch to the close of the Lignitic, the off-shore sediments appear to have been

pushed progressively farther and farther into the sea, and the depression accompanying the sedimentation appears to have been uniform throughout the area over which the deposits are now exposed; but the Lignitic epoch was apparently terminated by a depression (perhaps due to its own weight) of the margin of the subaqueous shelf thus formed, and a consequent increase in depth of the off-shore waters and in violence of waves and currents. These conditions induced increased heterogeneity and coarseness of deposits, the invasion of a deep sea fauna, and the entombment of its remains in littoral deposits. The formation thus developed we denominate the *Buhrstone*. The shore probably retreated rapidly and far inland during the Buhrstone epoch, particularly in its earlier episodes.

The Buhrstone epoch waned with the cessation of the seaward tilting; and, with the consequent reconstruction of a submarine terrace and some concomitant depression, there was introduced a slight physical change in the character of the deposits, without paleontologic break, marking the introduction of the *Claiborne*. Throughout the Claiborne epoch depression proceeded somewhat more rapidly than sedimentation, and with increasing depth of waters went increasing homogeneity and fineness of deposits.

The continuation of Claiborne depression was accompanied by gradual modification in physical character of the deposits and by differentiation of fauna, culminating in the latter part of the *White Limestone* epoch, when the Tertiary sea reached a depth approaching and perhaps equaling the maximum attained during the Cretaceous.

During the Claiborne and White Limestone epochs the distribution of sediments was apparently such as again to bring the sea bottom to approximate horizontality; and, with what appears to have been a sudden re-elevation of the land, conditions similar to those under which the Lignitic formation was laid down were once more introduced, and the shoal water strata of the *Grand Gulf* formation—the homologue of the Lignitic—were laid down upon the seaward margin of the White Limestone.

These shoal water deposits are followed by the deeper water and estuarine deposits of the *Pascagoula* which close the Miocene Tertiary.

Here, again, the conditions along the eastern and western borders of the state were essentially different. The barren Grand Gulf sands pass towards the east into the marine deposits of the Chattahoochee which are their time equivalents.

c. Post Tertiary.—While the development of the Coastal Plain has in general terms been marked by a progressive elevation (with the minor oscillations above recorded,) of the sea floor and a steady retreat of the coast line from the Paleozoic land mass towards the south and southwest, there have been two notable exceptions to this general order, viz: *a.* At the end of the Tertiary the mantle of loam, sands and pebbles of the Lafayette formation was spread over the entire coastal plain lapping furthermore well up on the Paleozoic terranes,—whether by virtue of a depression of the land and the invasion of the waters of the Gulf to that extent, or through the instrumentality of fresh water currents from the direction of the land, stimulated to greater activity by landward elevation, may not yet perhaps be positively asserted; the uniformity and vast extent of this mantle, which stretches over the entire coastal plain of the United States from the Potomac to the Rio Grande, pointing to the invasion of the sea, while the total absence of marine fossils and the structure of the deposits leave us in doubt about the validity of this explanation.

Whatever may have been the relative position of the land and water during the accumulation of the great mass of the Lafayette it seems certain that towards the end of the period the channels of main rivers of the state were at least 200 feet higher than now, and the conditions were favorable to the formation of a well defined terrace built up of the pebbles and loams which were also spread over the divides.

At the close of the Lafayette period the coastal plain was brought up to its present elevation, or possibly even higher, and subjected to a great amount of erosion by which this

mantle has been completely removed over great areas and greatly diminished in thickness probably over all.

The deposits laid down during this period of our physical history constitute the most widely distributed as well as in some respects the most important of our constituent strata, since they form the surface over a very good proportion of the entire coastal plain, and constitute the basis of the greater part of our most valuable soils.

b. A *fourth period* in this history of development may be found in the movements that inaugurated the undoubted Pleistocene of our section. The coastal plain was depressed sufficiently to allow the waters of the Gulf to advance at least 100 miles inland over the previously deposited strata and the marginal sea bottom thus formed to be covered by a mantle of sands. As this part of the coastal plain again emerged slack waters extended for long periods of time far up most of our large streams, allowing the deposition of those river margin sediments that constitute the "Second Bottoms."

The present river swamps and first bottoms, as well as the latest of the sand and mud deposits along the Gulf coast, constitute probably the closing scene in this development and the transition to the present order of things.

SUMMARY.

In summary the foregoing sketch of the geological history of Alabama may be given as follows:

An examination of the structure and distribution of the stratified rocks will show that Alabama has been built up, so far as its solid framework is concerned, of sediments which were accumulated under two widely distinct sets of conditions, whilst a great part of it in comparatively recent times has had a veneer of pebbles, sands, and similar materials spread over it.

These stages in the development of our state may be briefly summed up as follows:

1. The sediments which compose the northeastern two-

fifths of the state came from the waste of a land area that lay to the east of the present limits of the state and probably extended beyond the present shore line of the continent. The reasons for these conclusions are these: In going across this region from east to west we find the coarsest materials furthest towards the east and nearest to what was then the ancient coast line; in this part also we find the greatest thickness of sediments. Going westward these sediments become finer in grain and less in thickness, and limestones, an open-sea formation, make their appearance among the other rocks. This wasting away of the Atlantic continent continued for a long time, during which great masses of sedimentary materials were accumulated along the shores of the interior sea which occupied most of what is now the basin of the Mississippi, or else were spread far and wide over its bottom gradually silting it up, more rapidly along the coast line, less rapidly further seaward.

At the end of the Carboniferous period these long accumulating sediments were lifted above the sea, crushed together in numerous folds especially along the eastern border, and thus added to the dry land. This is the *mineral region* or paleozoic terrane.

2. The next stage in the history of the development of Alabama was the accumulation of sediments washed down from this paleozoic land mass and distributed over the floor of the great Gulf of the Mississippi, then covering the lower three-fifths of our area; the gradual elevation of these marginal sea bottoms into dry land and the steady retreat of the shore line of the Gulf to approximately its present position. The submarine deposits thus added to the dry land constitute our coastal plain, or *agricultural region;* geologically divided into Cretaceous and Tertiary formations.

3. With this the rocky framework of Alabama was completed, but a third period in this history is marked by the spreading of a mantle of loam, sands and pebbles over the entire coastal plain—whether by virtue of a depression of the land and an invasion of the waters of the Gulf to that extent, or through the instrumentality of great floods of

fresh water from the direction of the land, may not yet perhaps be positively asserted. Somewhat similar conditions upon a much smaller scale, however, prevailed later, and mark the transition to the present order of things.

In the preceding sketch we have spoken of the formations in their chronological order, since in this way the gradual growth and development of the material ground work of the state could be best presented. In the detailed report which follows we shall find it more expedient to consider these formations in the reverse order, beginning with those that are now forming under our eyes, of which the mode of accumulation, the details of structure, and the factors controlling their surface distribution, may be ascertained by observation, and proceeding to those more remote in point of time, and more difficult of explanation.

SECTION I.

GEOLOGY OF THE REGIONS CONTIGUOUS TO THE TOMBIGBEE, WARRIOR, AND ALABAMA RIVERS.

Historical.

In Bulletin No. 43 of the United States Geological Survey,* there is a sketch of the development of our knowledge of the geology of the Cretaceous and Tertiary of the Gulf states, which is here reproduced.

"In a memoir on the geological history of the Gulf of Mexico, published in 1871, Dr. E. W. Hilgard gives, in descending order, the following subdivisions of the Tertiary and Cretaceous in the Gulf states:†

* On the Tertiary and Cretaceous Strata of the Tuscaloosa, Tombigbee and Alabama Rivers, by Eugene A. Smith and L. C. Johnson.

† Proc. Am. Assoc. Adv. Sci., Vol. XX, p. 222, 1871; also Am. Jour. Sci., 3d ser., Vol. II, p. 391 and map, 1871.

			Feet.
Post-Eocene Tertiary	Grand Gulf group (brackish)		250
Eocene Tertiary	Vicksburg	Marine group	120
	Red Bluff		12
	Jackson		80
	Claiborne		60
	Buhrstone		150
	Lagrange	Lignitic group	450
	Flatwoods		
Cretaceous	Ripley group		350
	Rotten Limestone group		1,200
	Coffee (or Eutaw) group		300—400

Professor Angelo Heilprin,* using the publications of E. W. Hilgard, M. Tuomey, T. A. Conrad, C. S. Hale, C. Lyell, and A. Winchell, and manuscript notes furnished by the writer in 1873, has compiled the following section of the Eocene strata in Alabama:

	Feet.
White Limestone (Jacksonian)	50
Claibornian	17
Buhrstone (Silicious Claiborne of Hilgard)	250
Wood's Bluff and Bashi (Eolignitic)	50?

Our observations compel us to modify slightly the nomenclature of these authors and to modify materially their estimates of the thickness of the formations.

We are led to revive Tuomey's term White Limestone,† and apply it to the Vicksburg, Red Bluff, and Jackson divisions of Hilgard, since the collections recently made by Mr. T. H. Aldrich, but not yet described, show that there are very few fossils severally peculiar to any of these quasi-formations; and we are disposed to refer the several strata to the Upper Eocene. We are also led to divide the Claiborne of Hilgard into two formations, corresponding to his Calcareous Claiborne and Silicious Claiborne, respectively, and to restrict the term to the upper. We follow Tuomey‡ and others in denominating the lower formation the Buhrstone. Again, we are unable to discriminate the Lagrange and the Flatwoods of Hilgard; and we find the formation including these divisions to include also several beds containing marine fossils.§

* Contrib. to the Ter. Geol. and Pal. of U. S., pp. 29, 30, 1884.

† First Bien. Rep. Geol. Ala., p. 154, 1850.

‡ First Bien. Rep. Geol. of Ala., p. 143, 1850.

§ This formation has been denominated Eolignitic by Heilprin (Proc. Acad. Nat. Sci. Phila., p. 159, 1881); but the law of priority demands the retention of the name Lignitic, which was used in the same sense by Hilgard in 1860 or earlier. Once more, we feel compelled to restrict the name Eutaw to the glauconitic sands, laminated clays, micaceous sands, &c., beneath the Tombigbee sand and above the Big Log Shoals horizon. And, finally, for reasons stated fully on a subsequent page, we apply the name Tuscaloosa formation to the fossiliferous clays, purple clays and associated rocks exposed on the Tuscaloosa River from Tuscaloosa to White Bluff aud at many localities between the Tuscaloosa and Alabama Rivers.

The three Cretaceous formations are easily distinguishable along our rivers as distinct rock masses; but in constructing our sections we have been constantly confronted with the difficulty of fixing their boundaries with precision, since they appear to shade into one another, lithologically at least, by almost imperceptible gradations. Thus we are not sure that any of the outcrops along either of the rivers show the contact of the Ripley beds with the upper part of the Rotten Limestone. The contact of the lowermost strata of the latter formation with the underlying sandy beds is clearly enough seen at several places, at Erie and Choctaw Bluff, Tuscaloosa River, and at House Bluff, Alabama River, &c.; but below the first 15 or 20 feet of these sands the strata for nearly 300 feet (and, indeed, to the base of the Tuscaloosa formation, perhaps 1,000 feet lower still) are exceedingly poor in fossil remains, except those of vegetable origin, and even these are almost indeterminable. Dr. Hilgard considers these fossiliferous sands (his Tombigbee Sand group) as more nearly allied to the Rotten Limestone than to the Eutaw group, and if we class them with the former then the line between the Rotten Limestone and the Eutaw groups will come somewhere within the first 20 feet or so below the base of the calcareous part of the Rotten Limestone. The limit between the Eutaw and the Tuscaloosa formation, in like manner, is ill defined. It may further be mentioned that we have not seen in Alabama any beds which we can identify as belonging to the Grand Gulf age.

Our estimates of thicknesses vary considerably from those of Hilgard, partly, at least, because his estimates do not represent the thickness at any one locality, but the maxima in the Gulf States, and partly because our estimates are based on careful measurements of actual exposures of which only a part have hitherto been examined.

Since our route described two approximately parallel lines at right angles to the strike of the strata, we have generally been able to supply the breaks in continuity of exposures along one river by satisfactory exposures at corresponding stratigraphic horizons on the other, or at some points inland but contiguous to the water courses.

In the Tertiary formations at two horizons only have we been unable, by the combination of undoubtedly overlapping sections, to perfect our stratigraphic column. These breaks, which, upon an assumed uniform dip of 30 to 40 feet to the mile, cannot involve more than 50 feet each, probably much less, we have left blank. The black clays at the base of the Tertiary are exposed along the Tombigbee River from Black Bluff to Naheola, a distance which, with such a dip as that assumed, would correspond to a thickness of 260 feet.* These

* A re-examination of the exposures of these black clays in the summer of 1886 has convinced me that no reliance can be placed upon the dip in estimating the thickness, for the clays undulate very considerably. One bed in the black clay, for instance, was traced down the river (across the strike) for several miles, with scarcely any change in its height above the water level.—E. A. S.

clays are much thinner on the Alabama River, and in the Bladen Springs boring, as we interpret it, the thickness is about 100 feet, which we have adopted in our section. The apparently much greater thickness indicated by the exposures along the Tombigbee is probably due to undulations in the strata.

Our estimate of the total thickness of the Tertiary formations, ranging from 1,630 to 1,700 feet, is considerably larger than any hitherto made. It is, however, a minimum, as may be seen from our plates giving the overlapping sections from which the stratigraphic column has been constructed. This estimate finds a strong corroboration in the records of borings made in Meridian, Miss., and at Bladen Springs, Ala. The former boring was commenced in the upper strata of the Lignitic, just beneath the Buhrstone, and it is certain that the Rotten Limestone of the Cretaceous was not reached at a depth of 980 feet. At Bladen Springs the surface rocks are the Hatchetigbee beds, immediately underlying the Buhrstone. In this boring the Rotten Limestone was reached at 1,220 feet and the boring terminated in that formation at a depth of 1,345 feet. Accordingly, while our estimates of the aggregate thickness of the Tertiary formations of the Alabama and Tuscaloosa Rivers doubtless include minor errors, we have, we believe, a nearly complete and generally accurate section of the strata exposed on these rivers.

In the case of the Cretaceous our observations have less completely covered the ground, and we have been forced in some instances to rely upon estimates based upon an assumed seaward dip of the strata of 40 feet to the mile. This rate of dip agrees with the average of our observations and is corroborated by the record of the boring for an artesian well at Livingston, in Sumter County. The thickness of Rotten Limestone penetrated in this boring is 930 to 950 feet, and the width of the belt in which this is the surface rock in this part is about twenty-four miles across the strike of the strata. In the Ripley division we have, we think, a nearly complete section from our observations. In the Rotten Limestone we have the record of the Livingston well. In the Eutaw formation we have to rely in some degree upon estimates, though we have at Eutaw, on the Tuscaloosa, and at House Bluff and at Cunningham Bluff, on the Alabama, as we believe, nearly if not quite the complete series.

The materials of the Tuscaloosa formation, clays and loose sands, make comparatively little show along the Tuscaloosa River. Our column of this formation is accordingly very imperfect, and the estimate of thickness is based altogether upon an assumed dip of the strata of 40 feet to the mile.

The following table exhibits, in condensed form, our subdivisions of the Tertiary and Cretaceous formations of Alabama as exposed along the Tuscaloosa, Tombigbee, and Alabama Rivers; together with the carefully estimated thickness of each:

				Feet.
Tertiary. (Eocene)	Upper—White Limestone		Coral Limes. (Vicks.?)	150
			Vicksburg (orbitoidal)	140
			Jackson	60
	Middle—	Claiborne		140–145
		Buhrstone		300
	Lower—Lignitic..		Hatchetigbee	175
			Wood's Bluff	80–85
			Bell's Landing	140
			Nanafalia	200
			Matthew's Landing & Naheola	130–150
			Black Bluff	100
			Midway	25
Cretaceous	Ripley			250-275
	Rotten Limestone			1,000
	Eutaw			300
Cretaceous (?)	Tuscaloosa			(?)1,000

Our investigations relate chiefly to the formations below the White Limestone, and more especially to those underlying the Buhrstone, of which, so far as we are aware, no connected account has hitherto been published.

Our itinerary notes have been assembled and digested and the various exposures of the two waters are described together in the inverse order of antiquity. The leading phenomena are recapitulated in the description of the general section."

Present Classification.

Bulletin No. 43, above quoted, was concerned only with the Cretaceous and Eocene Tertiary formations, and our subsequent work has not thrown any new light upon those deposits along the two rivers of western Alabama, except that a study of some of the plant remains from the Tuscaloosa deposits shows that a part at least of that formation occupies about the same position as the Amboy clays of New Jersey, that is, the base of the upper Cretaceous. From analogy of the Tuscaloosa with the Potomac formation we may further be justified in concluding that a part of our Tuscaloosa will be found to belong to the lower Cretaceous. In any event the position of the Tuscaloosa as a member of the Cretaceous is fixed beyond doubt.

Since 1886 the later deposits of our Coastal Plain have been under examination, and the observations have been extended eastward to the Chattahoochee river, and southward to the Gulf, thus giving us a survey of the whole

coastal plain. These investigations carried on by Mr. Langdon, Mr. Johnson and myself, have added much to our knowledge of this part of the State, and have added to our geological column much that was not taken into account in Bulletin No. 43. The chief additions are: (1). The recognition of the Grand Gulf beds, and the definite determination of their geological position as lower Miocene, and the fixing of their equivalence with the Miocene beds of the Chattahoochee. (2). The discovery of a new upper member of the Miocene, viz., the Pascagoula. (3). A classification and description of all the post-Miocene deposits of the Coastal Plain up to the recent coast sands. This includes the Lafayette, the several terraces of the rivers and Gulf, and a mention of the deposits now in process of accumulation.

The subjoined table presents the classification most in accord with the present state of our knowledge of the formations of the Coastal Plain, and the following pages are devoted to their description in detail.

For the account of the Eocene and Cretaceous along the Tombigbee, Warrior, and Alabama rivers we follow closely our Bulletin No. 43, but the rest is here presented for the first time.

Tabular View of the Geological Formations of the Coastal Plain of Alabama, with the Approximate Thickness of each:

POST-TERTIARY OR QUATERNARY.

RECENT.

1. Coast sands and alluvium, upper part of the Biloxi..10 to 100 feet.
2. First bottoms and other alluvial deposits of the streams.
3. Soils and rainwash.

PLEISTOCENE.

1. Coast deposits, lower part of the Biloxi.....150 to 200 feet.
2. Mobile Bay Formation. (Mon Louis Island).....undetermined.
3. Second Bottom Terraces of the rivers undetermined but over 60 ft.
4. Ozark or Conecuh Sands. Sand Terraces.....undetermined.

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1. Third Terraces of the rivers (surface deposits)... ...10 to 20 feet.
2. The Lafayette Mantle. (Orange Sand. Appomattox)..25 to 200 feet.

TERTIARY.

MIOCENE.

1. Pascagoula.....Thickness undetermined, about 200 feet.
2. Grand Gulf..... " " at least 500 "

EOCENE.

1. St. Stephens, White Limestone. (Vicksburg and Jackson).....200 to 350 feet.
2. Claiborne..... 450 "
   a. Claiborne proper..... 150
   b. Buhrstone..... 300
3. Lignitic.....825 to 850 feet.
   a. Hatchetigbee..... 175
   b. Bashi or Wood's Bluff..... 80—85
   c. Tuscahoma or Bell's Landing..... 140
   d. Nanafalia..... 200
   e. Naheola, or Matthews' Landing.....130—150
   f. Sucarnochee or Black Bluff..... 100
4. Clayton. (Midway)..... ..... 25 to 200 feet.

CRETACEOUS.

	West Ala.	East Ala.
1. Ripley.....	250—275	1000
2. Rotten Limestone or Selma Chalk.....	1000	000
3. Eutaw.....	300	300
4. Tuscaloosa.....	1000	500

POST TERTIARY OR QUATERNARY FORMATIONS.

The relative position of the Post Tertiary formations of the Gulf States is sometimes difficult of exact determination, because contemporary causes wide apart geographically and in their nature, may be producing effects entirely dissimilar in character and disconnected; or more than one agency may be in operation in one and the same place, bringing about complicated phenomena. Where ocean sediments alone are under consideration the problem is comparatively simple; but where we have deep water, shore lines, lagoons and estuaries, fresh water streams and floods, all energetic at the same time, varied effects must be the result, and often without tallies to mark the agencies employed.

These formations fall naturally into two classes, the first of which would include all soils, first bottom deposits, river swamp and delta deposits, sand bars, dunes, etc., now in progress of formation or attributable to causes now in operation, more properly, perhaps, to be classified as *Recent;* while the second class would include somewhat analogous accumulations of a preceding period, when the altitude of the land was different from what it now is, and might properly be assigned to the *Pleistocene.* As a matter of course, since the present position of land and sea has been attained very gradually, these two classes grade imperceptibly into one another. In both classes, we may easily discriminate two contemporaneous and equivalent series differing in their materials of construction and in their included fossils; these are the deposits formed along the river courses and inland, and along the Gulf and Bay coasts respectively.

A. GULF COAST FORMATIONS (BILOXI), IN PART RECENT.

Inasmuch as the deposits accumulated along the coast of the Gulf of Mexico, exhibit most clearly the gradual passage of Recent into Pleistocene, they will naturally first claim attention. It will be seen that the practical continuity of these deposits make it impossible to draw any sharp line of demarkation between the two time divisions into which

they must fall, and we shall therefore speak of them together.*

No sufficient exposure in this state, have afforded good opportunities to study the nature and structure of these "Coast Sands," but enough is seen to identify them with their westward continuation along the Mississippi Sound, where at the numerous settlements, well borings, railroad and other industrial excavations have led to a very fair knowledge of the stratigraphy. The best opportunity, perhaps, is to be found at the town of Biloxi. Here the Sound is at its best; there is a back-bay receiving several small rivers, which come from older formations; and many Artesian wells have been bored to supply its fish and oyster ware-houses and "canning factories." One of these flowing wells is over 800 feet deep, with so large a head of water as to supply the water works of the enterprising little city.

Provisionally, then, and for the sake of convenience, we have applied the name Biloxi to the Coast formations, as they appear along this part of the Gulf.

The general character of these coast lands has been well described by Dr. Hilgard,† who says, "Between Biloxi Bay and Bay St. Louis, the pine meadow lands do not, as a general thing, approach so closely to the beach as is the case further east. Between the two, there intervenes a tract of level pine woods, the soil of which is very sandy, and the undergrowth intermediate in character between that of the "Meadows" and the "Pine Hills." The soil of the seashore hommocks also is extremely sandy; close to the beach, the pitch pine invariably prevails, together with the live oak, while a little further inland, on the elevations, we find the long-leaf pine, and in the wet flat depressions or "hollows" intervening between them, there is a growth of bay, black gum, willow and live oaks, some hickory and magnolia."

* In what follows under this head, we are indebted chiefly both for the matter and the form of presentation, to Mr. L. C. Johnson, who has given a good deal of time to the investigation of these deposits, and who has suggested the name Biloxi.

† Agriculture and Geology of Mississippi, p. 379.

Genesis of the Formation.

The factors co-operating to build up the Gulf front of Alabama have been three: (1) the waves of the ocean, (2) the Mississippi River, and (3) the united rivers that pour their waters into Mobile Bay. At the extreme east the waters of Perdido Bay make a contribution, and so does every creek from the highlands, emptying into the Bay and Sound; but for present purposes the modifying effects of minor agents may be overlooked and attention confined to the three mentioned. We may at the beginning confine our attention to one only, the Mississippi River. The effect of the ocean may be presumed, it acts everywhere and on all alike.

Not often within historical times has the Great River extended its arms as far as the Alabama coast, but in the spring of 1890 it made an effort to do so, and though with comparatively slight effect, sufficiently it is thought, to throw a strong light upon the process which, in times not very long past, geologically considered, has built up the ground work of four of our southern counties, at least one of west Florida, and the southern portions of Mississippi and Louisiana. Regarding this illustration as so impressive and important, it cannot be deemed a digression to give some particulars of the remarkable occurrence referred to.

The Nita Crevasse.—On the 13th of March, 1890, the levee at the Nita Plantation, about two miles above Convent on the left bank of the Mississippi River, gave way before the flood then at its height. According to the best information to be had at present, though not perfectly satisfactory, this point is 21 feet above mean high tide. About opposite the break is the head of Blind Bayou, the main affluent of this part of Amite River, and the stream that drains the back swamp of all that portion of fertile river front immediately above New Orleans.

The flow of the current at the crevasse during the period of high water was at the rate of 15 miles an hour. Yet, not until March 22nd, (9 days after the break), did Lake Mau-

repas become fillled up and the current begin to set into Lake Pontchartrain through the Pass of Manchac. By April 13th, the boundary lines of these lakes were obliterated and there was one turbulent sea of yellow water from the 28th mile post on the I. C. R. R. out of the city, to the 46th, 18 miles in width, poured through the outer lakes into the Mississippi Sound. By the first of May, old fishermen of New Orleans and Biloxi declared they could perceive a distinct current passing eastward beyond Ship Island; and by color and taste, the effect of the fresh water was appreciable as far as Grant's Pass, on the very entrance into Mobile Bay.*

Whether perceptible or not to the fishermen, the presence of crevasse water was very appreciable to the fish: it drove them all out of the Sound and from the Chandeleur Banks. From the eastern part of this district, about Dauphin Island and Petit Bois, the fish were not long absent, but as late as the 1st of June, the Sound was distinctly muddy at Mississippi City and Gulf Port; and seining parties, instead of pompono, sheep head, Spanish mackerel and red fish, took Mississippi cat fish and buffalo.

Of late years a considerable industry had grown up in the cultivation and canning of oysters, and all the banks or reefs as they are called locally, along the shores of Lake Bourgne and the Sound were becoming planted with the highly valued bivalves. To a very great extent the oyster beds as far east as Ship Island are ruined as well as all on

* Between Cedar Point, and Little Dauphin Island, a space of two miles is filled with reefs and sand bars caused by the meeting of the current from the Mississippi Sound with that from Mobile Bay. The currents are not all tidal, nor altogether dependent upon the winds; considerable variations are caused by the supply of land water from the rivers. We have seen, that when a large part of the water of the Mississippi River, was pouring into the Sound it caused an eastward current which might reach even to Mobile Bay, provided, as was the case in April and May, 1890, there had been a deficiency of rain in Alabama, and the rivers consequently were low. When the rivers of the Mobile estuary are full, the Alabama current prevails, and has a westward relief at Grant's Pass. When both currents flow in their strength at the same time, the silt of each must be dropped, and the islet and bars on either side of Dauphin Island receive accessions.

both sides of Cat Island. Investigations by parties interested have revealed these facts.

The interest geologically is that the invading floods from the crevasse brought vast amounts of mud. It was this solid matter held in suspension, and not the freshness of the water, that drove out the fish accustomed to the clear medium of ocean streams, for the silt clogged up the delicate organs of aeration, their gills, and they and the other marine creatures upon which they depended for food, beat a retreat. But escape was not possible to the sedentary molluses, and very soon, or about the 1st of April, oysters brought into Gulf Port were found to be uneatable and canning of them had to cease. Those who saw it say there would be pellets of mud in the folds of the mantle. By the last of April, it was discovered that the oysters on many of the "reefs" were dead, and the stench from them was intolerable to those passing over them in boats. This destruction of life was due to the sediments deposited upon the banks; oysters and their fellow colonists, unable to get away were covered up—literally fossilized.

The floor of the Sound has always been famous for its fine sandy bottom, the delight of bathers. The seining parties above alluded to, as early as the middle of May, reported the bottom from ankle deep to knee deep in a soft yellowish brown ooze. Allow for some exaggeration on their part: there is none in the report of Capt. W. H. Hardy, president of the Gulf & Ship Island R. R., and himself an owner of extensive oysters reefs: nor in that of Mr. Geo. Dunbar of the Dunbar Sons Packing House of N. O., which agree in the main fact, that thousands of acres of the banks are covered many inches deep in a brown muddy sediment. It was in similar way (possibly) that the fossils of this formation and of the next older, and of the next, back to the Grand Gulf, were preserved. In this way but few at a time, and at comparatively long intervals could have been buried in a material suitable for their preservation. For in the process of coast-building, the next step after deposition of the slime for mortar, was the laying down of sand by the tides

from storms. In 1872, and 1874 the Bonnet Carré Crevasse produced similar effects upon the fishing and oyster banks of the Sound, yet the mud laid down by that, (which continued open eight or ten years), was soon covered up by ocean sand. The report of Maj. Whenery the able engineer of the N. E. R. R., upon the structure of the bottom of the Mississippi Sound, shows that it consists of alternate thin layers of sand and of a soft bluish or brownish clay: for such a process as described above has been going on for ages.

It is understood thus far that we have had under consideration the effect of the second great factor the Mississippi River, modified by the first, that is, by the tide water meeting and stilling the currents from the Mississippi. Nearer the source of the outlet or river bank, it teaches other lessons. The water first rushing through the crevasse, tore up the soil, rooted up the trees, and floated off houses and everything movable. It made no deposits, naturally, before reaching the back swamps, and still water. Though where sufficient obstructions existed (as in case of many stranded houses and timber lodged among the trees), long ridges of silt or more sandy material were formed, which could contain nothing except the ruins brought by the flood. And so generally through the bayous, there was too much current for the deposition of much sediment. Where still water reached out, as over the large "pine meadow" or "prairie," between Manchac and Pontchatoula, and generally along the low parts of the north bank of Pontchartrain, the deposit was a fine mud, to be added to similar sediments which have formed the clays of that region. None of these contain, generally speaking, organic remains, such as might become fossil: none could contain *marine* fossils. Yet evidently the mud of the "oyster reefs" of the Sound, and that of the "pine meadow" flats of the Lake are of the same age and genesis; the circumstances and modifying agencies differ.

Recent explorations and principally artesian borings,

prove the making of many feet of the coast to have been similar to the late work of the Nita Crevasse. The first 350 feet of the boring of the great well at the Biloxi water works, according to Mr. Frank Sutter of the Sutter Company who superintended the enterprise, exhibit this section.

Section of the Biloxi Boring.

No. 1.	Top soil and sand	15	feet.
2.	Marsh mud, usually has fossils but none in this boring	1½	"
3.	Coarse beach sands	23½	"
4.	Gray mud, (usually has fossils, none here)	30	"
5.	Sands with water	10	"
6.	Hard blue and mottled clay	112	"
7.	Greenish sand with small stream of water	3	"
8.	Stratified clays	155	"
9.	Sands with water	5	"

The next strata below this are referred to the Lafayette formation which was penetrated for many feet, and which do not so much concern us at this point.

As the upper or recent part of this formation occupies but a narrow strip of the Alabama coast, and probably nowhere exceeds a few feet in thickness, it will be sufficient to describe it as consisting essentially of thin alternating strata of sand and sandy clay. It is quite variable because in progress of its structure old beaches, and marshes both salt and fresh, were worked in with regular strata: and now when exposed along the shore, appear as patches of black bottom, often studded with old stumps.

A good instance may be seen at the most eastern wharf at East Pascagoula, Mississippi. Stumps are seen in the clear water several hundred yards out in the bay, and are said to occur in as much as 10 feet water, and to be of cedar as well as cypress and pine. The neighboring land reveals the history of such a formation. Not far off there is a small old salt marsh which in process of time had become shut off from the bay by an ordinary sand dune, and thus freshened it, not only lost its marsh grasses and fauna of *Venus* or *Gnathodon* and *fiddlers*, but became a cedar brake, with a few stunted cypress trees in the lowest spots, and surrounded on the edges where sands were encroaching, by the common coast pines. At another point

farther on, we find where the tides have ruptured such a sand barrier and resumed sway over the low ground. Here the cedars and cypress are all dead, and mud and sand are settling around the roots. Natural decay in time (if not sooner aided by the hand of man) will remove the exposed portions or tops of the trees whilst the stumps will be buried in the mud and preserved forever. Many other instances could be cited. This was doubtless the history of the Cedar Marshes of South Carolina, where many trunks still stand like old gray monuments, and with their fallen and buried brothers are still a source of this highly prized timber. Fossils being always regarded as of supreme importance in stratigraphy, anxious inquiry has been made for any findings of the kind in the artesian borings of the coast. It is a little remarkable, that at the deep well at the water works at Biloxi, no fossils were brought to the surface. Fossils found at other borings were at too great a depth to have belonged to the superficial part of this formation now under consideration. A list of them will therefore properly come up under another head.

In other excavations in Mississippi shells in abundance were found, as for instance, just above water bearing sands 30 feet from the surface, on the L. & N. R. R. at Scranton in an excavation for a water tank. These shells are similar to those now found in the river marsh at Moss Point. Such old mud flats are often struck in the digging of wells both in Mississippi and Alabama, and furnish fossils of the living Gulf fauna, and detestable water. Localities in Alabama are not numerous because the high lands of the Lafayette approach very near the coast and furnish supplies of water. Grand Bay station on the L. & N. R. R., is located between high hills of the Lafayette, the drainage of which opens out to Franklin Creek running northward into Escatawpa River. The excavations for the tank at this place penetrated thin layers alternately of clay and sand 12 or 15 feet, when the black sandy mud was reached containing leaves and fetid water. It is stated that many clam shells and one specimen of fiddler crab were thrown out in the black mud. These things are popularly well known, though *Gnathodons* as well as *Venus mercenaria* are called clams, but there is only one fiddler, (*Gelasmus vocans*). At 20 feet red solid clay or hardpan was reached, (Lafayette, like the hills,) and 10 or 12 feet deeper good water in abundance in the same material.

At the entrance of Mobile Bay, the third factor of this coast, the Alabama River made its influence felt. Having been more directly applied as might be expected, it is at this point the main factor. This river comes directly from the ferruginous hills, reinforced by all the petty sand-bringers that flow into the bay, and doubtless has furnished the

larger portion of the material. Modern as the upper part of the Biloxi is, what is seen is only a remnant of what once was. At the Five Island west of the Mississippi,* it appears to have been swallowed up entirely, if it ever existed there, and it is now being washed into the Gulf along the Alabama and Mississippi fronts. But under the alluvium of the great delta it is still preserved, as revealed by many of the artesian borings in New Orleans and vicinity.

Comparison with the Port Hudson.

In the Biloxi section above given, the uppermost of the strata may be considered as recent and the lower as Pleistocene, though the line between them must be necessarily somewhat arbitrarily drawn. Mr. Johnson has just shown how the floods from the Mississippi River have been active in contributing in recent times to the sediments now accumulating along the shores of Mississispi Sound to the very border of Alabama, and he shows below how the more ancient alluviums along this same coast may be attributed in part to the similar agencies. An acquaintance with the Pleistocene formations of the Mississippi River is hence necessary to the proper understanding of the sediments of corresponding age in all the contiguous territory. These deposits were first described many years ago by that most sagacious of Southern geologists, Dr. Eugene W. Hilgard, and were by him named Port Hudson, from their typical locality. His section is as follows:

* Hilgard, Geological History of the Gulf of Mexico, p. 14.

Port Hudson Sections.

NEAR SAWMILL, PORT HUDSON.	No.	BELOW PORT HUDSON.
Yellow surface loam.....4-6 ft.	6	Yellow loam, sandy below, 8-10 ft.
Yellow hardpan..... 25 ft.	5	White and yellow hardpan. 18 ft. ..... Orange and yellow sand, sometimes ferruginous sandstone, irregularly stratified .8-15 ft.
Heavy greenish clay..... 7 ft.	4	Heavy, greenish or bluish clay..... 7 ft.
Gravel, sand, and clay in irregular bands, like river alluvium; with pebbles, driftwood, leaves and mastodon bones . . 6 ft.	3	White, indurate silt or hardpan ..... 18 ft.
Heavy, greenish or bluish, massy clay, similar to No. 4, 25 feet visible.	2	Heavy green clay, with porous calcareous concretions above, ferruginous ones below; some sticks and impressions of leaves. 30 ft.
	1	Brown muck, ... White or blue clay } with cypress stumps. 3-4 ft.

In commenting upon these strata Dr. Hilgard says, "the stump stratum No. 1 was visible to the thickness of 10 feet at its highest point; showing several generations of stumps above one another, also the remnants of successive falls of of leaves and overflows. The wood is in a good state of preservation; no prostrate trunks to be seen at present.

"The main clay deposit, No. 2. varies but little in general character * * * * The upper portion of the stratum, especially near its southern end, contains strings of calcareous nodules on stratification lines, eight to twelve inches apart. No fossils save rare impressions of leaves. No. 3 is exceedingly variable. At the northern end of the outcrop it is a narrow band of swamp deposit; at the first of the profiles given, it bears the character of a sand bar; lower down it returns to that of a swamp deposit; still below it is represented by a fine white silt, without a trace of vegetable remains. Lower down again, a lignitic layer appears at its base, with leaves and fruit of living species of lowland trees; while near Fontania, it is again a sand bar, with an abundance of prostrate trunks of driftwood, coarse sand, and pebbles.

"The green clay stratum No. 4 varies little, either in thickness or composition, and, like the stump-stratum No. 1, forms a convenient level of referenee.

"The hardpan stratum No. 5 I conceive to be the more immediate representative of the Loess proper, with which it is connected by gradual transition. * * * It is void of fossils."

Dr. Hilgard next calls attention to the fact that all these strata except Nos. 1 and 2 are extremely variable and are such as are shown in ditches cut in the modern river deposits. "The stump stratum, however, exists at about the same level, not only over all the so-called delta plain of the Mississippi, but also higher up, perhaps as far as Memphis, and all along the Gulf coast, at least from Mobile on the east to the Sabine river."

"Wherever circumstances allow, the overlying clay stratum No. 2 is also observed. These facts indicate the wide spread prevalence, during the epoch succeeding the Drift, of quiet, shallow fresh water lagoons and swamps of slightly varying elevation, through which the continental waters may for some time have found an outlet without a definite channel representing the Mississippi of to-day."

A few additional words of explanation are perhaps called for in order to show clearly the relationship between the Mississippi deposits and those of the Alabama coasts and river terraces.

The yellow loam of Mississippi is a fine yellowish, reddish or brownish sandy loam devoid of stratification lines, and of any considerable amount of lime. This loam covers a great extent of territory in Mississippi and is one of the most recent of the Pleistocene formations, following next after the alluvial deposits of the rivers. The Loess is a fine yellow calcareous silt, also devoid of stratification lines, but extremely rich in lime which in most places appears in the form of irregular concretions or "puppets" of carbonate of lime. This formation seems to be confined to the banks of the Mississippi river, and is now universally acknowl-

edged to be essentially a product of glaciers, and therefore is not to be looked for along those rivers that do not reach as far north as the glaciated region. Along the Mississippi it changes somewhat in character towards the south as Mr. Johnson points out below. It is to be observed however, that the two upper members of the Port Hudson section above given, are to be considered as representatives of the *loess* and not of the *yellow loam* proper. In most places the loess contains abundances of shells of land snails but no other fossils.

Mr. Johnson's observations, below given, confirm the explanation given long ago by Dr. Hilgard of the structure of the coastal strip, and bring out well the relations of the coast deposits of Alabama and Mississippi to the typical Port Hudson of the Mississippi River.

According to these observations, the land shells which are so characteristic in the upper part of the Mississippi basin, at Natchez begin to diminish in quantity, and at Bayou Sara, Port Hudson, and at Baton Rouge, they disappear altogether. A gradual change may also be observed in the lithological characters of the loess. At Natchez there is a beginning of a differentiation between the upper and lower strata; at Baton Rouge the upper part becomes a decided yellow loam and the lower layers become an intractable material called "hardpan" by Dr. Hilgard, and this is the most persistent portion towards the east, and the part with which we have here most concern. Thus the beds which are known along the upper Mississippi as loess and have the form of a fine grained calcareous silt, change towards the south into a yellow loam, which towards the east is more or less mingled with clay so as to become of the nature of a hard pan, impervious to water.

The lower members of the Port Hudson section are also the product of running water and are composed of materials of glacial origin and are therefore not to be looked for at any considerable distance from the great river which brought them southward. Nevertheless it is manifest that the Mississippi River had then the same habit it has

now, a straining to turn up the coast and flow eastward. And though much of the material, especially the sand and small pebbles would be left behind, it might carry on the greater part of the volume of the formation in its clays. And we find that (as in case of the Nita Crevasse, comparatively small as that current was), silts and mud were carried to the very shores of Alabama. At a former period when the "Passes," (that is mouths of the river) were probably in the vicinity of Baton Rouge, some great current carried this Port Hudson material represented mostly by the clays, across southern Louisiana, and across the State of Mississippi into Alabama, on the flats of Escatawpa river, and would have carried them into Mobile bay, but for the interposition of the lofty ridge of Lafayette sands, &c., extending from above Citronelle to Grand Bay. The great clay beds of Pontchartrain, equivalent to the Port Hudson extended, are the basis of the "Pine-Meadows." They exceed 100 feet in the borings at Biloxi, and at Scranton, Miss. At this last point the deposition of the formation was probably modified by contributions from the Pascagoula system of rivers, as well as by the Ocean. Possibly there is a thinning out of the deposits in Mobile county, and a great modification of it by a mingling of sands from the great ridge above mentioned.

Whether there is any real genetic difference between the Loess and the Port Hudson other than the order of deposition, the lowest and therefore the oldest members of this section have received the latter designation, and there is no good reason discussing it here, and seeking change. It is these members from 1 to 4 inclusive, (of the Port Hudson sections on a preceding page,) that we find spreading along the northern shore of Lake Pontchartrain, underlying the alluvium of Pearl river, modified and reapparing beyond, and underlying and constituting the terrane of all the region of the "Pine-Meadows," together with a variable fringe to the northward, covered by washings from the

sand hills, and an undefined portion of the territory covered by the coastal sands, above more definitely called "Biloxi."*

Additional Notes of the Extension of Port Hudson Strata.

The following details of observations by Mr. Johnson along the Gulf coast of Louisiana, Mississippi and Alabama, west of the Escatawpa river, will serve to bring more prominently forward the modifications which the Port Hudson equivalents undergo as we come eastward, and at the same time will serve to explain the characters of the Pleistocene deposits of the Gulf Coasts.

Referring to the Port Hudson sections above given, we find that the hardpan No. 5 or some similar clay may be followed from Pontchartrain Lake eastward to the high divide of Mobile county. On the N. O. & N. E. R. R., it is seen at Slidell station, obscured by the alluvium of Pearl river at Honey Island; it again is the surface at Nicholson, but soon to be lost at the foot of the high hills of Orange sand. Nothing can be more distinct and unconformable than where it rests, butt-up against the steep hill-side of the older much eroded Orange sand. Always the upper or exposed surface seemingly with little or no dip, and remarkably similar,—at least from the Pearl to Escatawpa river. What variation there is arises from the loss of coarser materials as we advance eastward. So much so that it gets the local appellation of "pipe-clay," in south Mississippi, and becoming more and more impervious to water, it is the rational explanation of the "Pine Meadows." On the rivers, and to the north and the east, it is even more extensive than in the undrained and undrainable pine-meadows. Along the rivers the surface gets a seasoning and tempering from river silts: and at the foot of the sand hills northward, and of the great Mobile divide eastward, there is a coarser tempering from sands washed off of these hills. No terrane, no group of strata have clearer and more readily recognized characteristics than this Pontchartrain phase of Port Hudson formation, whether we see it in local

*This name as originally applied designated merely the recent part of the Gulf coast formations, but it was found convenient afterwards to extend it to include also the underlying Port Hudson equivalents. This course seemed to be called for, for the reason that no definite line between recent and Pleistocene could be drawn in the midst of these sediments, which seem to have been built up under conditions which have persisted without essential change from the beginning of Pleistocene times. Whenever the term Biloxi, however, is used in contradi-tinction to the Port Hudson or its equivalent, Pontchartrain, it refers to the more recent portion of this coast formation.

freshly eroded surfaces, in river bluffs, ordinary wells, or in the deep borings of artesian water works. It does not clearly appear at the Port Hudson section, where in fact as clay, it is thinner than any where else, but it is not a solid uniform mass of intractable clays: there is some stratification: layers are reached bearing water, therefore more or less sandy, and arising from the contributions brought down by the smaller rivers and numerous streams running at the time of their deposition from the great hills of the Lafayette formation. The nature of these superficial interchanging strata, is well shown at Ocean Springs where the upper Biloxi sands and marls have been removed. The existence of these thin beds of intercalated sands is the explanation of water rising in all the wells in the region that pierce the first bed of tough variegated clay. Most of the wells on the coast only reach this impervious clay, and get water in the lower layers of the Biloxi. In many, however, the Biloxi sand is not sufficiently deep to hold a permanent supply of water, while a continuance of the excavation generally gives such a supply.

One instance is given by Dr. Hilgard in his report on the geology of Mississippi, in case of the McRae well already mentioned at West Pascagoula. Another farther from the coast is more notable. Seven miles north of Scranton, at Turner's old rice mill, on the only permanent stream (and it dries up in very dry seasons), between Moss Point and Americus, and on the first clear exposure of the "Pontchartrain," there is an old well dug in superficial sand 12 feet down to the firm clay. This well had a chronic habit of going dry in the summer. No ordinary deepening and enlarging of the water box sufficed to remedy the defect. Remaining dry in the uncommonly droughty fall of 1889, the proprietor undertook to bore down into the clay to see how far he would need to go to find water. This he did after digging a short distance with pick and spade. His boring reached 15 feet, when sandy material was struck, and the water rose immediately 19 feet, or to within 8 feet of the surface. At that height it probably drains off through the superficial sand. For some distance farther north, this, according to information received, was the general rule in digging wells in the "pipe clay," to-wit: the Pontchartrain. On Amite, Tickfaw, Tangipahoa and Tchefunckte, the yellow loam of No. 6 spreads over the surface, and if there were sufficient underdrainage, would produce a good soil. As it is, it furnishes the "brick dirt" for extensive industries. Eastward of Bogue Falaya, the fine loam seems to thin out. Not deciding or determining that these clays are identical with any of the lower members of the Port Hudson formation, I have heretofore called them provisionally the "Pontchartrain," and propose to prove that they form a quite extensive portion of that region heretofore without analysis, called the worthless coast sands.

If objected, that in the Pontchartrain clays of S. E. Louisiana, and

the "Pine Meadows" of Mississippi, the deposits are wanting in the gravelly "pinnacle sand," and in the calcareous "puppets" which stud the brown silty clays of Port Hudson, the Nita Crevasse supplies an answer. It is not reasonable to suppose that the fresh, cold current, however strong at the river, could transport a sandy material far out over grassy flats; and whenever the same silt-laden stream came to the salt Gulf water of the coast, by another well known law of chemical action, *lime solutions were necessarily surrendered, before it could pass farther up the coast.

Thickness of the Biloxi.—The low degree of dip, estimated at only 5 to 10 feet to the mile, is no criterion by which to estimate the thickness of the formation, as it lies upon the steeply inclined surface of the Lafayette. Accordingly we find in the borings of 30 to 40 wells upon the coast, the "Pontchartrain" clays very much exceed in thickness all that is seen of them on the Mississippi river. Analysis of the profiles of these wells as given by Mr. Sutter of Biloxi, the engineer who sunk them, after a varying thickness from 10 to 100 feet of upper or recent Biloxi is taken off, gives a pretty satisfactory result of an average of over 100 feet. At Bay St. Louis and at Biloxi there was under the coast sands an unmistakable thickness of these tough clays, of 115 feet. At Scranton they were a little thicker. It is reasonable to set down the formation at some 125 feet, with an allowance of 50 feet more to leave in dispute. If we could estimate any dip at all, that is only about half what it should be, considering the extent of surface covered, which at widest point observed above Americus to near Moss Point, is about 30 miles. It is to be remembered, however, that this formation was not laid down like one of the conformable Tertiary deposits, evenly one upon another, but wound narrowly around the foot of the great sand hills in Hancock and Harrison counties, and spread far up the already excavated valleys of the Pascagoula and Escatawpa rivers, receiving reinforcements from them in Jackson and Mobile counties.

Equivalents of the Biloxi.

Strictly speaking, the Port Hudson of Dr. Hilgard is confined to the Mississippi river and a few miles from its banks,

*A Geikie Text Book of Geology, p. 400.

and the form or modification of it appearing further out towards the east is here called for convenience, *Pontchartrain*, which though reaching up on Escatawpa river and some of its smaller tributaries in the south-western part of Mobile county, can not be said to pass around into the Mobile estuary, by reason of the Lafayette barrier above spoken of.

But surely its contemporary and homologue is there, though the comparatively short rivers from comparatively low mountains of Alabama, may not have deposited any *loess*, (grinding action of glaciers to prepare the material being absent), yet there was doubtless much energy of floods during this period in the South. The abundant evidence reported to exist of floods which took up and re-worked the Lafayette sands of the Atlantic Southern States, should have some counterpart in the Gulf region. In the Eastern states such re-worked deposits are extensive, and have there received the name of the *Columbia formation.*

Only the Mississippi of our Gulf tributaries could have produced a strict counterpart to them, and this it has done in its Port Hudson and Pontchartrain clays, the eastward extension of the same, and perhaps also in the beds of drift-like sands lying to the northward of the greater part of the Grand Gulf region of Mississippi.

In Alabama then west of the dividing ridge of Lafayette sands of Mobile county, along the lowlands of Escatawpa river and of the coast, it is probable that the strict equivalents of the Port Hudson enter into the composition of the Biloxi formation.

We shall presently see that to the east of the dividing ridge above mentioned, and beyond the reach probably of the influence of the Mississippi river, a contemporaneous deposit was accumulating, in many respects similar to the Port Hudson clays, but lacking the calcareous concretions though filled with the stumps and other vegetable remains that are so characteristic of the Mississippi river formation. This stump-bearing clay borders the Bay of Mobile and extends up the larger rivers to the inland margin of the coastal plain. Associated with it on the Bay coast we find

beds containing oysters and other forms now living in the waters of the open Gulf beyond, and this phase of it we have called the *Mobile* or *Mon Louis Island* terrace, while the fluviatile phase has received the name of *River Terraces* or *Second Bottoms.*

Recent Subsidence of the Gulf Coast.—Before proceeding to trace the connection of these coast formations with those encountered along the shores of Mobile Bay, it may be well to speak of the movements of the land along these coasts in Pleistocene and recent times, and here we find that all the facts give evidence of a slow subsidence now going on, at least from Santa Rosa Island to Lake Pontchartrain. It is slow and has not been of very long continuance. Of the littoral islands, Cat Island, Ship Island, Dauphin Island and others, to which the tides are always adding sand, have been left as somewhat higher wooded points in the sinking and subsequent scouring out of the areas of the bays and sounds. The rapid deepening of the Gulf here outside of them, shows it is not long since the land was higher. The underlying hard clays beneath the alluvium prove the same thing. Upon these estuaries there is another proof of the subsidence which is also attended with something of a gauge of duration. Whilst it goes to show the exceeding slowness of the movement, it also has this ethnological bearing, that the elevation subsequent to the "drift" period* had come to a stand-still, or had nearly if not quite ceased, when the shell-heap makers arrived. Some of these shell-heaps are out in the midst of the marshes above Mobile, and there is reported one beyond the railroad bridge at Scranton, Miss., in a situation where it is not reasonable to suppose human habitations would have been located, if the ground then had been a marsh as it is now. Excavations for the railroad levee at the latter point indicate that the shell-heap was upon the underlying hard bottom, and not upon such a spongy mud as now covers these flats. So much going to imply a previous elevation: the same "shell-heaps" furnish

*Hilgard Hist. of Gulf of Mex. 12—end.

argument of the recent slow, continuous subsidence. Far up the rivers, the small shell deposit on Leaf river, from Eastabuchie to Augusta, and several seen as far south as Americus on Pascagoula, consist only of *unios*, *vivipara*, *physa*, &c., fresh water forms now living in the streams. Lower down the heaps become more considerable, with only a few *unios*, the great mass consisting mainly of brackish water *gnathodons:* still lower oyster shells begin to appear among the gnathodons: and near the sea the shells are all marine. Upon the Pascagoula this grading can be most easily observed and its significance understood. At Moss Point and above the junction with the Escatawpa, the shells are wholly gnathodon, though some oysters are now found in the river near at hand. At Scranton oysters are now plentiful in the river, yet the large shell-heaps at the saw-mill below the railroad bridge, and a little lower still at Mr. Delmas' house, have the lower tiers almost wholly of gnathodons, a shell not now living in the salt flats; and the upper wholly of oysters, the intervening portions being mixed. Oysters have come up the bay, and thus far up the river with the encroaching salt water, whilst the gnathodons have retired to the mud banks above Moss Point.

Dr. Hilgard gives evidence of a similar subsidence of the Louisiana coast, west of the Mississippi delta—only there it has not progressed so far. There you find still stronger evidence of the preceding elevation. For instance brackish water gnathodons are still abundant in Lake Charles, holding their own even after the water has become fresh. Similar instances of salt water fish and even *algæ*, I have found in fresh water lakes of the coast of Florida, as in lake Majorca at Pinellas, Hillsborough county. The occlusion of the last though is within the last 20 years, and it might still be filled from the Gulf in case of a long continued westerly or south-westerly storm. Evidence of a similar and contemporaneous subsidence on Mobile bay and affluents, is abundant. Having been better observed by Mr. Toumey under more favorable auspices, I shall refer to his account for details, only giving certain important conclusions.*

* Second Biennial Report, pp. 151-158.

The "truck" garden of Messrs. Strouder and Lallemand he found located upon a large shell mound in the midst of the marsh 12 miles above Mobile, the top not above the highest water mark now, but an excavation 10 to 12 feet in it showed the same gnathodon shells with vestiges of Indian art to the bottom, below ordinary stage of water.

The sands of the immediate Gulf shore constitute wave-built walls or incipient dunes, a feature common to all subsiding coasts.* The long semi-island from Fort Morgan to Point Urno, the entrance to Perdido Bay, belongs to this class. So do Dauphin Island and Petit Bois. In the history of the French settlements there is evidence to show that 200 years ago these formed one long spit or key seven leagues long. Encroaching waves, devouring their own offspring, have made two islands of it, as we have them now, and are still consuming Petit Bois at both ends.

B. ESTUARINE OR TRANSITION FORMATIONS (MOBILE).

Within the lines of the great "Keys" a terrace-like flat fringes around the highlands of Mobile and Baldwin counties, which nowhere exceeds a mile in breadth. At Daphne it is wholly wanting, and is very narrow at Grand Bay and Bayou Labatre. Up Fowl river and Dog river, these flats spread out into "Pine meadows," a little more extensive, but which may be considered, at least in main part, as river bottoms.

Fowl river has two outlets, one entering the bay, the other to the south empties into Mississippi sound. In this way is cut off a long strip of the coastal flat to make Mon Louis Island.

This locality has recently been examined by Mr. D. W. Langdon who furnishes the following:

Section on Eastern Shore of Mon Louis Island.

1. Light red, yellow, and gray mottled argillaceous sand, the clay increasing toward the bottom where signs of lamination appear..... 8 feet.

*McGee, Isostasy of the Gulf of Mexico. Am. Journ. Sci. Vol. XLIV p. 177.

2. Laminated slate, blue, fine grained, sandy clay; pyritous and showing efflorescence of ferrous sulphate, but containing no trace of organic remains..... 6 feet.
3. Highly ferruginous sandstone, filled with shell casts, *Ostrea virginica, Arca transversa, Pecten sp., Mytilus hamatus, Cardium magnum. Natica duplicata*..... 2 inches.
4. Greenish gray mud, the same as dredged out of the channel of Mobile Bay, filled with shells mainly *Ostrea virginica*, and *Mytilus hamatus*..... 3 feet.

These fossiliferous deposits continue along the coast line for several miles, the elevation of the oyster bed (3.) varying from nothing to three feet above mean tide. The appended section will give some idea of the structure of the coast. On Maj. Clitheral's place, N. E. $\frac{1}{4}$ of N. E. $\frac{1}{4}$, Sec. 30, T. 7 S, R. 1, a well showed:

Section in Maj. Clitheral's Well.

1. Surface soil--mainly white sand..... 18 feet.
2. Oyster bed..... 18.20 inches.
3. Thick blue mud..... 8 feet.
4. Black swamp mud containing leaf impressions and old logs..... .....

About the same formation was found in a well dug in S. W. $\frac{1}{4}$ of S. W. $\frac{1}{4}$ Sec. 28, T. 7 S, R. 2.

The dredging of the ship channel from Fort Morgan to the city, revealed similar fossils and a hard bottom of blue mud, similar to that struck in the wells upon the Island. The collections saved by Maj. Damrell, who had charge of the work, were submitted to Mr. T. H. Aldrich and to Dr. Wm. H. Dall, gentlemen best acquainted with our recent and later fossil fauna and according to their judgment these molluscs are all now living in the Gulf. According to Mr. Langdon, wells dug some distance inland as well as upon the Island, expose fetid clays with sticks of wood and leaves and cypress stumps.

Further up the coast towards Mobile, beds exhibited along the shore are slightly different, for the oyster and shell bed appears to be wanting and the deposits become entirely similar to those making up the second bottoms of

the river. Thus at the Toll House a mile or two below the city, the following section was exposed by the ravages of the storm of October, 1893:

Section at the Toll House.

1. Surface, shell road..... 6 inches.
2. Yellowish sands, bluish black above from admixture of vegetable matter. This sand contains a good deal of impalpable ochreous matter..... 5 feet.
3. Transition bed, mottled sand and clay, the latter segregated in small lumps, more properly described as yellowish sands with lumps of gray clay..... 1-2 feet.
4. Layer of lignitic matter..... 6 to 12 in.
5. Blue clay containing many stems and other fragments of wood, bituminized on the outside, but of the nature of rotten wood inside; this extends down below the level of tide.....6 feet and more

In this section the layer containing the oyster shells is conspicuous by its absence, and in general, the wells dug in the city of Mobile reach the fetid blue clays with vegetable matters at depths of 20 to 30 feet below the surface, and that without encountering the shell bed. So also at Pritchard's station 3 miles above the city, wells show the existence of the fetid clays with sticks and leaves at the depth above given, but no shells. On the other hand, the boring for artesian water in the city of Mobile, in the first 100 feet brought up sand, clay, and fragments of shells, apparently from depths below that at which the blue clay is reached in the ordinary wells, but it is impossible to say with certainty at what particular depth the shells were reached. In the same boring, fragments of ligitized wood were encountered below 100 and above 130 feet; and still below this, many feet were penetrated of sand, clay and small gravel, evidently belonging to the Orange Sand or Lafayette. From this record we may infer that here the conditions favorable for swamp and estaurine deposits persisted long enough to allow of the accumulation of more than 100 feet of strata. The sections at Mon Louis Island, at Maj. Clitherall's, and at the Toll House represent the upper parts of the formation, while the Mo-

bile boring shows the depth to which these and similar strata extend; but as has been said, from the nature of the method of boring, it is impossible to give with certainty the exact depth from which any particular object was brought up.

We have therefore in the Mobile formation a Post-Tertiary or Pleistocene formation, younger than the Lafayette, and older than the outside "Keys," and older than the first bottoms of the rivers, and formed during the last great depression of the coast, preceding the last considerable elevation, and of course, preceding the subsidence that is now in progress.* The shells which characterize the formation could not have flourished here except at a time when the Mobile estuary was freely open to the deep sea. This would make it contemporaneous with the lower part of the Port Hudson and Biloxi above described, and the section at the Toll House shows that it corresponds also with the older part of the second terrace deposits of the rivers. But this will be made much clearer below when we come to give the characteristics of the river terrace strata. It will thus be seen that the Mon Louis or Mobile formation forms a natural connection between the marine Pleistocene of the outer coasts on the one hand, and the fresh water Pleistocene deposits of the rivers on the other. The full extent of the formation is not yet certainly known. Pretty certainly it continues on to Escambia Bay and Pensacola Bay, where the shelving shore as in case of Mobile gradually slopes under the waters of the bay, and dredgings at the long wharf built out at Pensacola for the cars to take coal out to sea-

* The economic bearing of these discoveries upon this section of the state is most important. Whenever an appropriation from Congress is asked for the purpose of deepening the harbor, objection is made on the plea that it is useless to dredge out a channel that is being constantly filled by every freshet. While there is little doubt but that the sediments brought down by fluvial waters act toward this end, it is also evident that the greater part of the material now being dredged from the channel was deposited by influences no longer in force. In other words, the shallowness of Mobile Bay is the result more of an elevation of the old coast line than of silting from the waters of Mobile River.—D. W. L.

going ships, brought up the same gray blue clays as at Damrell's canal, and containing the same *Natica*, *Nassa* and *Arca*, as Mon Louis Island. Mr. T. H. Aldrich who was interested in the wharf and the ships taking coal from the "Cahaba Coal Co.," got quantities of the dredgings, though most of it was dumped out in the bay, and has determined the shells found in the clay. Now this tough clay is of a moderate thickness, and iron pipes driven through it to underlying beds of deep sand obtained an abundant supply of water for shipping, which rises above the surface and flows directly to points required. The deep beds of water-bearing sand are doubtless of the "Orange sand" or Lafayette formation which approaches within sight, and at one point less than a mile from salt water.

C. FLUVIATILE AND UPLAND FORMATIONS.

The Upland formations would include all soils and rain-wash now in course of accumulation and not connected with the water courses. In another Volume, (Agricultural Report, 1881–2), the subject of the Soils of Alabama has been treated somewhat fully, and we may therefore omit its further discussion here. There is, however, one variety of formation, upland as to present position, possibly coastal as to origin, which will find mention below, viz: the Ozark or Conecuh sands, which also occur as a river and creek terrace.

River Terraces.

The rivers that traverse the Coastal Plain of Alabama, in the wide valleys which they have carved out of the underlying Tertiary and Cretaceous rocks, in the deposits with which they have subsequently partially filled these valleys, in the still more recent re-excavation of these filled-in materials, and in the accumulations now in progress, have left permanent records of recent geological changes, and of the fauna and flora of their banks. These changes can in no way be more simply described than in connection with the terraces, of which along most of the streams of this

region, we may readily distinguish three, and in many places, a fourth.

(1.) The first terrace above the water constitutes the *First Bottom*, subject to annual overflow. These are similar everywhere. Their marine equivalents would be the wave-washed, wind-driven sands of the keys and bars of the coast, and yet how different in every particular except the one factor of time.

Strict alluvium consists of the washings of the upland soils, and varies in material from a loamy sand to a fine mud mixed with vegetable matter. In geographical distribution these deposits are of course confined to the immediate vicinity of the streams where the waters have deposited them along the banks, or at the heads of the bays where the currents have met the still waters of the Gulf. Though confined to this small territory the fresh water alluvium throws light upon other questions. One of the first things to notice is the great similarity attending its development upon all these rivers of Alabama, at least as far east as Escambia Bay.

The alluvial plain of the two main rivers of Alabama though united, as compared with that of the Mississippi, is small in extent; and does not reach much nearer than within 30 miles of the actual Gulf line, the distance between Fort Morgan and Mobile.

A large proportion of the loose materials taken up by the rains will be washed off into permanent streams and by them transported far from their place of origin. As the brooks flow together to form larger streams each bears its tribute of soil and mineral matters washed from the lands which it drains. The sediment of a great river therefore includes material brought from all the various regions traversed by its tributaries. With every diminution in the velocity of the current from change of slope or change of the volume of the water or from friction against the banks or bed of the stream, a part of the suspended matters will be deposited. Where obstructions occur along the course of the river, eddies and moderately still waters will be pro-

duced, and a gradual silting up will follow. This happens on the concave side of every bend of a river, where the widest and most valuable of the bottom lands are to be found. When, however, the waters rise out of their banks and spread over the flood plain, the matter held in suspension, will be deposited in parallel zones, the coarser particles along the immediate bank of the stream where the current is swiftest, and fine sand and still finer clay further back in the river swamp, where the comparative absence of all current permits the complete settling of all the matter held in suspension. The soils of the river swamps and bottoms thus accumulated are of extraordinary fertility, but have the serious drawback that they are liable to periodical overflow.

Notwithstanding all this, a large proportion of the sand and finer sediments is carried down either in suspension in the central and swiftest part of the current, or rolled along the bottom, till the stream reaches the still water of the Gulf or Bay into which it empties, where the greater part even of the finest particles is deposited, gradually silting up the mouth of the river and forming a delta, unless where the tidal currents are effective to wash them out to sea to be deposited as bars, or to be carried far and wide by the moving waters. Where the waves break full upon the shores, they continually wash away the finer sediments leaving a beach of pebbles and sand, but where the shores are protected against the direct wash of the waves, as in bays, or where the waves break sideways upon the shores, the fine silt and clay will constitute the bottom. Sheltered places may gradually be silted up in this manner till certain plants take root upon them, and sea marshes are formed.

From this it will be seen how our first bottom lands have their equivalents in the delta deposits, and in the most recent of the Gulf shore deposits, and may vary from place to place from the condition of the finest of sediments to the coarsest of sands.

(2.) The Second Terrace, found more or less developed upon even the smaller streams of the coastal plain, is that

well known by its popular name "*Second Bottom.*" This terrace varies in width up to one mile, and is found at gradually increasing altitudes coming northward. Along the lower courses of our larger rivers they are not more than ten or fifteen feet in height, while near the fall line of these rivers they may be sixty feet or more above the low water mark. In material they are, considering their origin, remarkably uniform, being made up of sands and clays in varying proportions, the uppermost strata being usually of the nature of a fine yellowish sandy loam, while below the depth of ten feet, the sand becomes prevalent. The upper loam is used in many parts of the state for brick-making to which it is admirably adapted. These loams serve furthermore as the basis of many of the very best farming lands in the state. Near the water level we find very commonly underlying the sandy strata above named, a bluish clay containing many stumps, roots and other remains of vegetation, in a state of astonishingly complete preservation, considering the length of time they have probably been imbedded. This terrace also like the first, merges into an equivalent marine formation occurring along the Gulf coast and already described above as the Biloxi formation, the transition forms being seen along the shores of Mobile Bay, where near the city, they are the counterpart of the rivers' terraces, while further down the bay beds holding marine shells are interstratified with such as characterize also the river terraces. Of the substantial equivalence in time of the Second Bottoms with the Port Hudson of Mississippi, through the intermediate phases of Mobile Bay and the Gulf coast, I think there can be no reasonable doubt. But all this will be more apparent upon comparison of the detailed sections to be given below.

(*a.*) A good section of characteristic Second Bottom is to be seen at Logan's Bluff on the Tombigbee river in Hale county, and it may be taken as typical, except that the stump stratum was not seen there.

Section at Logan's Bluff.

1. Top soil six inches of grayish fine loam with a slight shade of yellow.

2. From six inches to ten feet, the proportion of clay increases and the material is a clayey loam of grayish yellow color.

3. From ten to eighteen feet the proportion of sand increases, the deposit below ten feet being a fine sandy loam of decided yellowish to reddish color, mottled with spots of light gray color, the sand grains quite small and well rounded.

4. From eighteen to twenty-five feet, yellowish to reddish sand, mottled with spots or streaks of gray to white sand all very fine grained; comparatively little clay.

The immediate channel of the river is cut into this material, and the lower beds being much more sandy than the upper, there is constant undermining and caving off going on on the outer side of the bends. The upper eight or ten feet of the bluffs thus produced are usually nearly perpendicular and comparatively smooth, while below, the bank has a slope of forty-five degrees or less, along which the rain has cut little furrows and ridges. As caving goes on, stumps and logs are frequently brought to view, which have been buried under these deposits. They are commonly supposed to be cypress stumps, and they are usually in a fairly good state of preservation. In some cases small beds of pebbles occur below the Second Bottom deposits, and from well borings in the lower courses of the Tombigbee river it seems that sands are again encountered below the stump stratum.

(*b.*) Near the site of Old Fort Jackson, a few miles below Wetumpka, the Coosa and Tallapoosa rivers, by reason of bends in each, have approached within a few hundred yards of one another, and in recent times a "cut off" has been washed out through all the Second Bottom deposits which form here an extensive plain on which are located some of the best farms of this whole section. This "cut off" has been washed down to the level of the water at ordinary stages, so that whenever either river rises a few feet above the ordinary level, the water cuts across into the other. The section exposed is about as follows:

Section at "Cut Off" near Fort Jackson.

(1.) Fine grained yellowish silty clay, the basis of the soils. This clay passes gradually down into more sandy material ..... 5–10 ft.

(2.) Gray sands, with very little clay except above near base of the preceding ..... 10–15 ft.

(3.) Heavy blue clay filled with stumps, twigs and other vegetable remains. These are all in perfect state of preservation, being in many cases like ordinary drift wood. The stumps terminate upwards in a great number of points ..... 6–10 ft.

The remarkable thing in this section is the great number of stumps and other remains with which the clay is filled. as well as their perfect state of preservation As this section is exposed entirely across the neck of land separating the two rivers, there can be no doubt as to the age of the strata exposed.

(c.) At McIntosh Bluff, on the Alabama river, some fifty miles above Mobile, we get another very good section of the Second Bottom deposits, exposed along the concave bank of the river here.

Section at McIntosh Bluff.

(1.)	Fine grained yellowish clayey loam, of the typical Second Bottom character. It makes the soils of the terrace	2 ft.
(2.)	Gray clayey sands mottled with red, and becoming sandier below	3 ft.
(3.)	Yellow sands with gray clay interbedded	3 ft.
(4.)	Light yellow cross bedded sands to water level	4 ft.

A short distance further up the bluff, there may be seen about the place of No. 3, or between Nos. 3 and 4 of this section, a mass of dark gray clay containing many carbonized or bituminized sticks and leaves.

The second terrace here extends out to the St. Stephens road, a distance of about a mile, and in many places where wells have been sunk. the blue or gray clay with sticks and other vegetable matters is reached at depths of 20 to 25 feet. Below the blue clay water-bearing sands are encountered within thirty feet from the surface.

Ozark Sands, and Sand Terraces.—In the lower part of the state we find, along the larger streams as an intermediate terrace, and along the creeks as the main terrace, a formation of gray sands, with pebbles in the lower parts, especially along the immediate courses of the streams.

The same sands also occur over the divides at altitudes up to 100 feet, and correspond closely with what Mr. McGee has described as the interfluvial phase of his Columbia formation. They form the basis of the greater part of our pine-covered lowlands.

As terraces along the rivers, especially the Chattahoochee, these sands occupy a flat some five to ten feet above the Second Bottom terrace, and of course to the landward of it, and are eight to ten feet in vertical thickness of strata, according to position.

Along the creeks they form the main terrace, and the materials characteristic of the Second Bottoms are then wanting. The terrace sands rest unconformably upon the red loam of the Lafayette, and as a rule the flats covered by these sands are much wider on the eastern or left banks of the creeks than on the opposite side, being in some cases a mile wide on the east and only a few feet on the west.

It is rare to find these sands and the typical Second Bottom loams in contact with one another, and for that reason their relative position is not easy to ascertain with certainty, but as they constantly appear as a terrace inland from the second terrace and a few feet above it, we may reasonably infer their greater age.

The *interfluvial or upland phase* of the sands is seen in most of the southern border counties in a mantle of sand, three or four feet in thickness, overlying usually the Lafayette red loam, and sharply distinct from it.

Where it is continuous and thick enough it forms deep beds of sand with a growth of the barren oaks, (black jack, turkey, and upland willow oaks), along with somewhat scrubby long-leaf pine. Typical exposures may be seen about Skipperville and Ozark in Dale county, about Geneva, and the lower parts of Covington, and Escambia, especially along Conecuh river.

In the central parts of the state the sand terrace appears to be generally wanting.

(3.) *The Third Terrace*, is found at elevations of 50 to 100 feet above the preceding, and in the central parts of the state is made up of a red loam with an underbed of pebbles and sand, precisely similar so far as one can see, to the mantle of red loam and pebbles, which under the name of the Lafayette formation covers interruptedly the entire coastal plain and it bears the same relation to this Lafayette that the sand terrace just described does to the Ozark or Geneva sands.

The third terrace is much wider than the first or second, being in places three miles or more in width. Upon it are located many of our most important towns and cities, such

as Montgomery, Tuscaloosa, Girard, (opposite Columbus, Ga., which is also upon the same terrace), Columbia, Eufaula, Jackson, Claiborne, etc.

Because of the identity of the materials making up the body of the third terrace with those of the Lafayette, and the very obvious connection between the two, this terrace will be spoken of more at length in connection with the Lafayette formation below.

MICROSCOPIC CHARACTERS OF THE SECOND TERRACE SANDS.

In this connection I may call attention to some interesting facts brought out by Mr. Cunningham through a microscropic analysis or examination of the sands about Whistler, near Mobile. This town rests upon the continuation of the Mobile second terrace, and while the surface material consists perhaps of 90 % or more of ordinary rounded grains of quartz or silica, Mr. Cunningham, also found a very considerable quantity of black sand consisting in the main of magnetic particles, which were in part crystals and rounded grains of magnetic oxide of iron, and in part magnetic spherules, showing regular reticulated surface, and reflecting the light feebly. Similar magnetic spherules were collected by Mr. Cunningham along the shores of Mobile Bay at Monroe Park. The origin of these spherules is still to be explained, though there are two or three rather probable conjectures. (1.) Mr. Cunningham thinks they may possibly be of organic origin, for following reasons. He described some time ago from the Miocene clays penetrated by an artesian boring at Mobile, some marine diatoms, fully *pyritized* or converted into iron sulphide. This material also contained along with the pyritized diatoms, millions of spherules of iron pyrites, which Mr. Cunningham suggests are pyritized *radiolarians* of the simplest structure, since silicious spherules with similar surface reticulations are common in the marine Miocene clays of the Maryland deposits. Mr. Cunningham also observed that when these

spherules of pyrite from the Mobile boring were heated, they were converted into a red oxide which was attracted by the magnet.

There is thus a close analogy between the pyritized spherules from the artesian well clay, from a depth of six hundred feet or more, and the magnetic spherules of the Whistler sands, except that the latter are black and do not reflect the light brightly, and exhibit a porous or granular texture when crushed. (2.) On the other hand, it is possible that these magnetic spherules are part of the matters ejected from coal burning locomotives, since it is known that such spherules are thrown out as products of the combustion of mineral coal under boilers, in foundries, etc. The finding of them along the shores of Mobile Bay at Monroe Park is not decisive, since steamers and locomotives pass that point at no great distance. (3.) Still another suggestion is, that they are characteristic of what is called "cosmic dust."

Among the heavy particles of black sand were observed many fragments of crystals whose color and other characters under the microscope, led to the suspicion that they were fragments of garnets, tourmalines, and other similar minerals, but they were not identified more closely. Other particles among the sands, were thought to be fragments of gypsum, from the manner in which they could be crushed between plates of glass and from the character of the crushed mass.

Of interest also were numbers of perfect doubly terminated crystals of silica(quartz),of small size, some pellucid, some containing inclusions of other microscopic crystals, as well as gaseous vacuoles. The presence of these perfect crystals among water-worn and water-transported material such as constitutes the great bulk of the sands, can be explained only perhaps upon the suggestion that they are of secondary origin, the result of the action of silicious solutions. We have analogous action in the petrification of wood, and the silicification of the Vicksburg lime-stone which is so common a phenonenon in southeastern Alabama and the ad-

joining parts of Georgia. Other illustrations might be citied beyond the limits of Alabama, but these are sufficient.

Below the buff colored sandy loam which forms the surface at Whistler, there are found beds of non-fossiliferous plastic clays interstratified with sands, and in some places at depth of 20 feet or more from the surface, a clay occurs which contains numerous vegetable remains. This has also been examined by Mr. Cunningham who finds by rough analysis about 90 per cent. of silicious, water-worn sand, mingled with 5 per cent. of clay, and about 5 per cent. of vegetable matters. This constitutes the clay so often penetrated in wells upon the Mobile terrace. The vegetable matters in this clay were found to be associated with a number of microscopic forms such as *diatoms* and *rhizopods*, and when subjected to the microscope the carbonized vegetable remains exhibited the vascular bundles, scalariform vessels, flat pitted duct vessels, etc., characteristic of such exogenous forms as ferns and mosses. In addition, this matter contained great numbers of spore capsules, and plant-stones or *phytolitharia*, as they have been called, the origin of which is still obscure.

All the materials included in the examination of the Whistler series belong in all probability to the Second Bottom or Second Terrace of Pleistocene age.

PALEONTOLOGY OF THE ALABAMA PLEISTOCENE DEPOSITS.

From what has been said above it will be seen that the fossils included in the deposits of this age are stumps, twigs, and other remains of trees which are still in existence, and shells of oysters and other genera which are now living, though in some cases not in the same localities where their fossil remains are found.

Through the labors of Mr. K. M. Cunningham of Mobile, a most enthusiastic student of microscopic forms, extensive deposits of Diatomaceous earth or true tripoli have been brought to light at Mobile and at Montgomery in deposits of

this age. In Mobile they have been found in the mud dredged from the bottom of the bay in opening the ship canal, where they are of marine and brackish water forms, while other deposits have been examined which are made up chiefly of fresh water forms.

At Montgomery the diatomaceous deposit forms a component part of the river terrace or Second Bottom, and but for the fact that the land upon which it occurs is in the midst of the city and therefore of very great value, this deposit would undoubtedly be profitable to mine.

At my request Mr. Cunningham has furnished a short account of these deposits together with a list of the forms which have been identified.

DIATOMACEÆ.

BY

K. M. CUNNINGHAM.

Fossil Diatomaceæ.—On May 8, 1891, while in Montgomery, Alabama, observing the character of the earthy strata along the Bluffs on the Alabama river, I found vast surface indications of an argillaceous substance, which upon further study with the microscope proved to be fossil infusorial earth, made up entirely of the remains of the Diatomaceæ. These organisms, while they are living in most waters of the globe, and are variously classified as fresh-water, brackish or marine species, have also in their fossil condition a wide distribution, as lacustrine or as marine deposits. The earliest of the sedimentary lacustrine or sub-peat, fossil diatomaceous deposits present themselves in the early period of the Post Glacial Age, and are found as such very widely distributed in Nova Scotia and the New England states, where they have been long known and studied. The deposits of Montgomery belong likewise to this comparatively recent period, since they are associated with the river terrace strata, and their study suggests a period of quiescence in the formation of these pebble and gravel-bearing strata, as the deposits occur interstratified with non-fossiliferous, sillicious pebbles and gravels, and as there are indicated evidence of a constant and uninterrupted deposition of diatomaceous strata ranging from five feet to twenty feet in thickness. Above the overlying beds of gravel, deep beds of alluvial or diluvial sands and gravels were deposited, thus suggesting a cessation of favorable conditions, or a change from a quiet, lacustrine basin to an active sand-moving and depositing force. Traces of plant remains

can be noted all through the fossil diatomaceous strata, but so attenuated as to leave a bare imprint therein.

I append herewith a list of the fossil species identified as occurring in the Montgomery Tripoli beds. A peculiar interest must attach to this fossil deposit of fresh water diatoms, as it appears to be the only one of geological importance, noted as found in the Southern states.

I might suggest that the fossil infusorial deposit at Montgomery, may become the nucleus of a large mining and milling industry, as the marine fossil Tripolis on the coast of Maryland are mined on an extensive scale, as stated in Bulletin No. 75 of 11th U. S. Census, on the "Minor Mineral Industries of the United States" for the year 1889. The Tripoli output of five Atlantic and Pacific Coast States was valued at twenty-four thousand dollars ($24,000) in round numbers, the prices ranging from $2.50 for the crude material at mine to $100 per ton for the Pacific Coast manufactured polishing powders. The bulk of the Tripoli mined, was mostly used in mixing with asbestos in about the proportion of one-half tripoli to one-half asbestos fibres and compounded together, and applied in the form of a cement-coating to steam boilers, and steam pipes as an economizer of heat and incidentally of steam; it also has a distinct use in fireproof and heat-resisting refractory coatings for structures exposed to the dangers of combustion. The Census Report fixes the amount mined at about 3,000 tons for steam coating purposes.

The Southern tier of states were not mentioned as having any tripoli works in operation in 1889. So that ten years must elapse before Alabama's deposit shall take its place in the next census. The vast tripoli deposits of Montgomery are better adapted to steam saving cement purposes than the Maryland tripolis, as the Atlantic coast range of tripolis of marine formation consist mostly of minute, flat circular grains, while the Montgomery tripoli is composed of spindle-like particles several times longer than wide, thereby felting and interlocking with a more natural cohesion when mixed with asbestos fibre.

The problems to study in reference to the development of this source, are the feasibility of mining and milling, and finding or creating a market for its consumption. When it can be easily shown that a single ton of a universally useful material can retail for $500 (the usual rate for 1-4 of pound of manufactured and boxed tripoli being about ten cents), the practical, money making economist may find it a profitable field to exploit and develop, thereby possibly adding another important industry to Alabama's many already developed resources. Tripoli has a varied and extensive application in the arts. Such as in the earlier composition of dynamite from nitro-glycerine; as a tooth dentifrice well known as sozodont; as a material for polishing silver and gold ware; glass; metals; machinery; and in fact for every substance that is capable of taking a polish or a shine. It is

supposed to be the material in which the celebrated and delicate cast-iron art jewelry, and novelty castings called "Berlin Work" are moulded in. It can be utilized with success in the manufacture of Ceramics or China ware and even porcelain, as a pure Silica is used in a variety of ways in the manufacture of art pottery, glass ware, etc.

(*A.*) *List of species of Diatoms occurring in the fresh water Lacustrine Deposit of fossil Diatomaceæ at Montgomery, Alabama.*

Amphora ovalis.
Cocconeis pediculus.
Cocconema cistulum.
" *lanceolatum.*
Cymatopleura elliptica.
Cymbella Ehrenbergii.
" *heteropleura.*
Encyonema triangulum.
" *turgidum.*
Epithemia gibba.
" *turgida.*
Eunotia diodon.
" *major.*
" *robusta.*
" *serrulata.*
" *turgida.*
Gomphonema acuminatum.
" *augur.*
" *constrictum.*
" *intricatum.*
Melosira crenulata.
Navicula Americana.
" *columnaris.*
" *cuspidata.*
" *Dariana.*
" *gigas.*
" *inflata.*
" *iridis.*
" *limosa.*
Navicula pachytera.
" *Smithii.*
" *transversa.*
" *trinodis.*
" *viridis.*
Nitzschia scalaris.
" *sigmoidea.*
" *tryblionella.*
Odontidium hyemale.
Pleurosigma hippocampus.
" *Spencerii.*
Pinnularia gibba.
" *nobilis.*
" *mesolyla.*
" *mesolepta.*
" *radiosa.*
" *rupestris.*
Surirella elegans.
" *craticula.*
" *spiralis.*
" *tenera.*
Stephanodiscus Niagarae.
Synedra ulna.
Stauroneis acuta.
" *gracilis.*
" *Phœnicentron with several unidentified species.*

Recent or living Diatomaceæ.—Apart from the interest in the study of fossiliferous beds of infusoria, there is a collateral interest in the study of the recent or living species of Diatoms. And among the localities that have contributed materially in this direction, the Gulf of Mexico and the bays indenting or bordering its coasts have for nearly a century held a conspicuous place; since as far back as 1850, the late Prof. J. W. Bailey of West Point, the U. S. Military Academy, made microscopic examinations of various harbor muds on the Atlantic and Gulf coasts, his observations having been published under the auspices of the Smithsonian Institution. As one of the earliest investigators, he described and named several new species, as derived from the muds of Mobile Bay. I have gone over the ground reported upon by him, and have extended the list of species observed very materially, so much so as to leave very little more to be added; nearly every imaginable depository of these unicellular

organisms has been explored, and the resulting species tabulated and listed. In addition to this, from Mobile as a distributing point, selections of the cleaned and concentrated diatoms have been forwarded to the leading cities of Europe where they have met with great favor and appreciation among the Diatomists of Europe, as well as those of the whole of the United States. There is a constant published demand from European preparers for the American recent and fossil, marine and fresh water diatomaceæ. At the same time, new and interesting deposits are being announced from widely separated parts of the globe, thus keeping up a continued interest in this branch of microscopic science.

It is estimated that eight thousand species have been described and figured to date while the literature, Monographs and publications are comparatively costly; but fortunately for those who desire to pursue this study, the Rev. Francis Wolle of Bethlehem, Pennsylvania, has recently published a list with figures of all species of the Diatomaceæ known to occur in North America. This work facilitates the identification of specific forms, in the hands of the student or geologist.

In the construction of the Sub-marine Channel in Mobile Bay hundreds of thousands of dollars have been expended by the U. S. Government for the removal of a sedimentary mud, very largely the result of the growth and destruction of a variety of microscopic life, as every sample of channel mud is made up of an infinity of remains of once organized life such as Diatoms, Rhizopods, Foraminifera, Sponge spicules, spines of Echinoderms, tissues of plants, pollen grains, and transported matter, in the nature of micaceous scales, and scilicious sand grains; the effect of this growth, operating for thousands of years would eventuate in shoaling and surrendering the bottom of the Bay to marsh growths, and eventually to an earthy or clayey formation, on dessication, analogous to the sedimentary marine strata containing organic remains of the higher divisions of the Tertiary strata. In proof of this being probable, I have recently demonstrated the existence of the richest diotomaceous stratum underlying a vast marsh tract bordering the western side of Mobile River at a point one quarter of a mile north of One Mile Creek, near Mobile, Alabama, where there is a stratum of mud underlying the rank marsh growth of rushes, canes, etc. The composition of mud for a depth of six feet being nearly to the extent of 50% made up of fresh water and marine diatoms (about fifty species), the carapaces of fresh water Rhizopods, shells of Foramimifera, sponge spicules to an extent of richness hitherto not known or even suspected. The discovery of this deposit was brought about by the owner of the marsh suspecting the presence of mineral oil in the mud; a portion having been secured for microscopic analysis, resulted in the interesting discovery of its richness in diatoms and other organic remains. The diatomaceous shells can be concentrated and removed to any required

quantity in nearly absolute perfection. Cleanings of this deposit have been widely distributed at home and abroad, through the kindly interest of Dr George H. Taylor of Mobile, whose celebrated cleanings of diatoms have made the circuit of the globe, meriting and receiving universal praise. It is also doubtful whether any enthusiast has ever prepared as large a quantity of marine diatoms from harbor muds as has Dr. Taylor.

TERTIARY FORMATIONS.

PLIOCENE.

THE LAFAYETTE FORMATION.

The strata which, in Alabama, next underlie, in regular order, the deposits above described as Second Bottoms, Biloxi, Port Hudson, etc., belong to the formation first named by Dr. E. W. Hilgard, "Orange Sand," afterwards in many publications spoken of as "Southern Drift," "Stratified Drift," or simply as "Drift." An equivalent or identical formation on the Atlantic coast received from Mr. W. J. McGee the name "Appomattox." For reasons not necessary here to detail it was thought advisable to select a name which should include all these beds heretofore known and described under the designations above given, and accordingly by agreement the name Lafayette, from the county in Mississippi where the formation was first studied by Dr. Hilgard, the eminent pioneer of Southern Geology, was proposed and accepted and will be used in this report.

In his report on the Geology and Agriculture of Mississippi, Dr. Hilgard has given an account of the Orange Sand of that state, which for fullness of detail and accuracy of description of materials, structure and occurrence, leaves nothing to be desired. Of late years Mr. McGee has carried his study of that formation over the entire coastal plain of the United States, from New Jersey to Texas, and has brought together a mass of observations which he has ar-

ranged with consummate skill, and from which he has been able to trace out the geological development of the coastal plain not only in its latest phases but from its beginning.

In the writings of these two authors we shall find everything of importance known concerning the Lafayette.

In what is said below concerning this formation in Alabama, my indebtedness to them can scarcely be sufficiently acknowledged.

Distribution.—While the materials of the Lafayette formation are to be found as a superficial covering over the entire coastal plain of the state, *i. e.* over all the Tertiary and Cretaceous strata, lapping in places even far over upon the edges of the Carboniferous and other Paleozoic terranes, it is only in the two Gulf-bordering counties, Mobile and Baldwin, that we find it forming one of the structural units, intercalated between the Biloxi and Second Bottom deposits above, and the fossiliferous clayey sands of the Pascagoula horizon below. Its place is thus definitely fixed in our stratigraphy, although there is still some question as to whether it should be classified as the upper member of the Tertiary, or as the lowest of the Post-Tertiary; cogent reasons have been presented for both courses. As regards its origin and mode of deposition we have likewise some difference of opinion among those who have most studied it in the field, but these arguments will be better appreciated after some description of its materials and its distribution in this state.

Although originally spread over the whole coastal plain, possibly in a sheet of somewhat uniform thickness, we find at the present time very considerable variations in this thickness, ranging from nothing to two hundred feet. It is of course entirely absent over all those territories occupied by the later formations, First and Second Bottoms, Coast Sands, etc., except where these have been denuded away so as to bring the underlying strata to the surface. In some districts it occurs to a limited extent only, and in this dis-

tribution it corresponds in Alabama very closely with what has been described for Mississippi by Dr. Hilgard. In a general way we find the thickness of the beds of the Lafayette to be less towards the inland margin of the Coastal plain, than further south near the coast: over the Carboniferous and other Paleozoic terranes we find it represented as a rule by mere remnants which in some parts of this territory occupy the summits of hills of considerable height, *e. g.* in Walker county, where small patches of pebbles and red loam have been encountered upon hills in the vicinity of the two forks of the Warrior river; and in Talladega, Calhoun and Cherokee counties, where within the limits of the Coosa Valley, small remnants of it are to be found at altitudes 200 feet or more above the river level, and as much as 600 or 700 feet above tide level. Another isolated area is in adjacent parts of Walker and Winston counties, near the town of South Lowell at approximately the same altitude.

The divide between the waters of the Tombigbee and the Warrior through Franklin, Marion, Winston, Walker, Fayette and Tuscaloosa, is a high ridge, nearly continuous, known as the Byler Ridge, with an average altitude above tide of say 600 feet. This ridge is everywhere capped by the pebbles and other materials of the Lafayette, and the country to the west of this ridge in Marion, Fayette, Lamar, and Tuscaloosa is more or less completely covered with these beds, even at lower levels than that of the ridge summit. Going from Tuscaloosa a little south of east towards Columbus, Georgia, we everywhere find this accumulation of pebbles, sands, and red loams occupying the summits of the elevations of 500 feet and above, and in many cases occurring also far below this altitude. This margin of the Lafayette we find therefore occupying practically the dividing line, or rather the line of junction, of the various Paleozoic formations, from Crystalline Schists up to the Coal Measures, with the oldest of the Cretaceous, viz., the Tuscaloosa.

Inland of this marginal belt of the Lafayette, which is across the state exceedingly well defined, we have only the remnants of the formation above mentioned, and some others of similar nature. This marginal belt forms rather an exception to what was stated above, viz., that the thickness of the formation decreases from the Gulf towards the north, for in places these beds remain still fifty to sixty feet in thickness, which is considerably above the average for the coastal plain as a whole.

Over the Tertiary and Cretaceous formations which constitute the basis of the coastal plain, we find the Lafayette present to a limited extent only in the following sections: (1) A very considerable proportion of the territory underlaid by the Rotten Limestone is free from the sands and loams of the Lafayette, and in these cases the materials of the Cretaceous formation come to the surface and produce the soils, which are of a marly nature and commonly known as "prairie" soils. (2) So also in the region formed by the black or gray clays of the Sucarnochee formation of the Tertiary, commonly known as the "Post Oak Flatwoods," there is little or none of the material of the Lafayette. (3) In the adjoining eastern parts of Choctaw and Washington counties, where the lower strata of the White Limestone, corresponding to the Jackson group of Mississippi, occupy the surface, we have very similar conditions to those prevailing in the region of the Rotten Limestone, and an almost complete absence of the Lafayette. (4) In some of the southeastern counties, especially Henry, Geneva and Escambia, the Lafayette is generally covered by the Ozark or Geneva sands which make the greater part of the actual surface, although the Lafayette is to be seen along most of the water courses and in some cases at considerable distances therefrom, where the overlying sands have been denuded away. Over most of the other portions of the coastal plain either the Lafayette is generally present, or the residual sands and loams

from the weathering of the Tertiary and Cretaceous strata that make the underlying formations, are so closely similar to some of the materials of the Lafayette as to make absolute discrimination in many cases impossible, and very frequently extremely uncertain.

This is in particular true as regards the lowest of the Cretaceous or the Tuscaloosa, which is composed of sands, clays, and pebbles. More particularly in the case of these pebble beds, we have found the greatest difficulty in discriminating between those of the Tuscaloosa and those of the Lafayette, especially in that section where they occur as a marginal belt across the state, as already indicated above. Here the pebbles originally deposited in the time of the Tuscaloosa formation, have certainly in many cases been rearranged and redeposited in Lafayette times, which makes absolute identification impossible. It may be said, however, that where we have had the opportunity of seeing these beds in close proximity or in actual contact, the pebbles of the Tuscaloosa seem to be more generally composed of fragments of chert, sub-angular or very incompletely rounded, and to be derived as a rule from the chert beds of either immediately underlying formations or of formations not far distant, and these are in most cases the cherty beds of the lower Subcarboniferous that underlie a great area in the Tennessee valley in the northwestern corner of the state. Over these subangular pebbles of chert, we have sometimes observed beds of well rounded pebbles of quartz (with a few of chert) mingled with the red loam or sand which is so characteristic of the Lafayette. But even here the presence of some subangnlar chert pebbles with the fossil impressions which indicate their origin, show some mingling of the older Tuscaloosa beds with the newer Lafayette.

And indeed, we find this admixture ot well rounded quartz pebbles with less rounded fossiliferous chert pebbles, to

characterize the accumulations of pebbles of the Lafayette down the rivers as far at least as Jackson in Clarke county.

Thickness and structure.—The variations in the thickness of the Lafayette are attributable, I think to two causes; in its original deposition it was probably laid down upon an uneven, eroded surface, and thus thicker in some places than in others, and secondly, it has in different localities, suffered very unequal amounts of denudation since its deposition. It seems further probable that the deposition of these materials extended over considerable periods of time, and some changes of level of the land areas were in progress during this deposition, so that while the accumulations were still in progress along the seaward margin of our Coastal plain, the landward margin was in part being denuded, and having its coating of Lafayette materials carried away, at least along certain lines. The greatest thickness over any considerable area is in the Gulf counties, Mobile and Baldwin, where it can hardly be less than 200 feet; and from that latitude northward, there appears to be a progressively decreasing thickness, varied with almost total absence of the deposits over certain areas, and exceptional thickness of them over others as above shown. The fact that the materials of the Lafayette were deposited upon an eroded surface seems to be proven by the circumstance that it may be found in beds of nearly uniform thickness in valleys, along slopes, and upon hill tops, differing in altitude by 200 or 300 feet, and in close proximity, and in such cases we have not been able to discover any very considerable difference in the thickness on hill tops, along slopes or in the valleys, nor are there any essential differences in the quality or arrangement of the materials in these positions. And still further, along all our important streams there is a terrace 150 to 200 feet above mean water level, and 100 to 150 above the level of the Second Bottoms, in which the red loam and pebbles of Lafayette *origin* at least, constitute the surface. And upon

these terraces the thickness and arrangement as well as the materials themselves, differ in no wise from what we see displayed along the slopes leading up from these terraces and upon the hilltops overlooking them often from a height of at least 200 feet. That the terraces are the result of river action is perhaps not to be doubted, but the materials and their arrangement are the same as characterize the Lafayette which is spread over the surrounding country, and it is impossible not to connect in the mind the formation of these terraces and the spreading of the Lafayette over the heights, as two phases of the same geological act, the terraces marking a last episode in the emergence from the depression which permitted the distribution of the pebbles and loams over the adjoining heights.

In its stratification the Lafayette is remarkably irregular, as might well be inferred from its mode of deposition (1) upon an uneven and eroded surface, and (2) in ever varying and strong currents. Where the sands are exposed in cuts and gullies, cross-bedding, or false-bedding is everywhere to be recognized as one of the distinctive characteristics of the formation. The pebble beds are equally irregular, as they thicken up into great pockets and thin down to mere strings and give out entirely, all within a few yards distance. This irregularity of structure and the fact that the sand grains and pebbles are all without exception well rounded and worn, have from the first been considered as sufficient proof that they were deposited out of flowing water, often with strong current.

Materials of the formation.—By far the most widely distributed of the Lafayette materials is a sand or rather a loamy sand, composed mainly of rounded water-worn grains of quartz, constituting from 80 to 98 per cent. of the whole. This sand like the pebbles, is almost universally stained with iron oxide which imparts to it at the surface where most exposed, a deep red color, while from depths of fifteen to twenty

feet the prevailing color of both sands and pebbles is yellowish. In some instances the sand is devoid of color, or is white. The sands towards the coast are in general terms less tinged with these colors than is the case further north, yet in the hills west of Mobile, (Spring Hill,) we have as characteristically colored red sands as any that occur over the country further north. All this color is due to the oxide of iron more or less hydrated. Under favorable circumstances and where the proportion of iron is sufficiently great, we find it more or less segregated, forming a cement to the sands and gravel, sometimes to a moderately coherent mass, sometimes to a firm hard ferruginous sandstone or conglomerate as the case may be. The sandstone masses are prone to form wherever the percolating waters charged with iron dissolved out of the surface sands, in their descent through the underlying masses, meet with some less pervious bed such as a clay or a hardpan. There the iron is deposited in solid form as a cement by which the sands are bound together into a firm rock. By subsequent erosion these plates and tubes of ferruginous sandstone, for they take all kinds of shapes, are undermined and broken down and left strewn in fragments along hill slopes, sometimes appearing almost like works of human art. The stones thus formed are rarely of any great thickness, three or four feet being above the average, but they have been used in places as a rough building stone and especially as material in the construction of pillars of houses, and of chimneys. At one place in Clarke county, I have seen the lower story of a dwelling-house made of this sandstone. Occasionally the percentage of iron increases to the extent of making these concretionary masses fairly good iron ore, and we have collected many samples of good fibrous limonite, needle ore in fact, from among the ferruginous masses of this formation, but it does not occur in this pure form in sufficient quantity in any locality known to me, to make it of any commercial importance. Where the Lafay-

ette or the Tuscaloosa* laps up over the Subcarboniferous of the Tennessee valley and over Silurian and Cambrian limestones of the Cahaba and Coosa valleys, we find among its materials fairly good beds of limonite which are of sufficient extent and purity to be worked for the ore. Of such origin in all probability are the ore banks near Vernon, in Lamar county, and near Russellville in Franklin county, and above Pratt's Ferry in Bibb county on the Cahaba river. In such cases where the Lafayette lies upon the Subcarboniferous and Cambrian formations, which are generally considered as the original sources of the limonite, (which may, however, have been accumulated in banks at any period since these rocks by tilting, fracture, and erosion, have been subjected to the leaching action of atmospheric waters,) it is not easy to divide the credit fairly between the two. It is a matter of common observation, that the formation of concretionary masses of limonite is in progress in hundreds of places at the present time, and the accumulation of ore in banks, i. e. the segregating or concentration of the iron, previously widely diffused through the solid underlying rocks or the loose surface sands, can not be assigned to any particular period, so that many of our most important limonite banks, may be, so far as their present form and position are concerned, of Lafayette age or later.

One of the most remarkable of the accumulations of this rough ferruginous sandstone that have come under notice is near Healing Springs in Washington county, in the "Iron Mountain," so called because covered with huge masses of this rock, sometimes many tons in weight. The layer of sandstone, formed just above a stratum of clay of the age of the Grand Gulf, has protected this particular

*In some of the instances cited, the Tuscaloosa as well as the Lafayette overlies the older formations named, so that it becomes at times difficult if not impossible to say whether the ore banks should be credited to the Tuscaloosa or to the Lafayette. In some cases we can be sure that they belong to the former.

spot from the denudation which has removed so much of the immediately surrounding country. In all the coastal plain where Lafayette has been spread as a covering, we find these plates of ferruginous sandstone sometimes several feet in thickness, more often only a few inches, protecting the underlying loose sands and pebbles from erosion and thus giving rise to the formation of rocky hills.

Mr. K. M. Cunningham of Mobile has made some interesting observations upon the ferruginous sandstones and conglomerates of this formation about Spring Hill and elsewhere. While examining these rocks about Mauvila he found among the fragments, a piece of oblong shape that had magnetic properties, or north and south polarity. At State Line, Miss., in a railroad cut, there occurs a thin sheet of this ferruginous sandstone lying between beds of pure white, incoherent sands. On examination of this rock it was found that its surface was studded with myriads of polished fragments of wood, petrified by ferric oxide, or converted into it. Again at Muscogee in Florida, near the line of Baldwin county, Ala., he obtained many specimens of trunks and roots of conifers, petrified in a similar way. The same form of fossil ore is also abundant in Baldwin county.

At Spring Hill Mr. Cunningham collected a lot of the small pebbles and other materials brought up by red ants and spread about their nests. Among these he found a number of fragments of ferruginous matters of general appearance of lumps of limonite but exhibiting strong magnetic quality. Some of these magnetic pieces are fragments of the petrified wood, in which the grain and structure are quite manifest.

Of almost universal occurrence through the lower part of the state are the red sandy loams which form the immediate surface. In by far the great majority of cases this upper red loam is from ten to fifteen feet in thickness, below it

come as a rule beds of pebbles of varying thickness, and below the pebbles, where they do not form the lowest of the beds of this formation, come the beds of yellow and orange sands above mentioned. The red surface loam constitutes the basis of a great proportion of the soils of the whole Coastal Plain of Alabama, and it has about 80 per cent. of quartz sand colored a deep red by iron, and mixed with aluminous or clayey matter to the constitution of a sandy loam. This red loam is far more widely distributed, at least in Alabama, than any other particular form of material, and may be seen at almost any exposure of the Lafayette.

After the sands and loams the materials most abundant are the beds of water-worn pebbles, which are usually of quartz, but sometimes of chert (a name applied to a great number of flinty or hornstone-like varieties of impure quartzose matters.) Like the sand grains, the pebbles are often strained with iron, and exhibit the usual variety of red and yellow colors. In places we find the pebbles free from any stain and exhibiting the colors of the original quartz. In distribution the pebbles are most abundant along the belt above alluded to, which extends from the north-western corner of the state around to Columbus, in Georgia, approximately along the line of contact of the Tuscaloosa division of the Cretaceous with the various Paleozoic terranes. In this respect the pebble bed appears to be of the nature of an accumulation along an ancient shore line. It may be remarked, however, that the Tuscaloosa formation which occupies very nearly the same ground, is itself distinguished by the great number of pebbles which it carries in certain parts of the state, and especially from Tuscaloosa city northwestward to the borders of Mississippi and Tennessee. Towards the east the pebbles of the Tuscaloosa are very much less abundant, though the Lafayette pebble beds continue in almost undiminished force, at least as far as Notasulga beyond the Tallapoosa river. To the southward of this belt,

the pebbles are not universally met with, but appear to be more or less closely confined to the drainage areas of the most important streams. I say drainage areas, for the reason that these pebble beds are distributed all along the slopes from the immediate channels of the rivers out as far as 25 or 30 miles therefrom. They are not commonly found in great quantity over the wide divides, but this may in part at least be from the fact that upon these divides the overlying red loam is not often thinned down or removed so as to expose them to view. However that may be, we hardly ever fail to encounter the pebble beds as we begin to descend the slopes from the divides down towards all of our principal streams, and in size and quality as well as quantity there seems to be very little difference whether we find them near the Paleozoic border or near the Gulf shore. Some of the pebble beds along the Florida border are as thick and contain as large pebbles as any in the state. In size these vary between wide limits: the great bulk of them are of the size of a walnut and smaller, while in places, often at a great distance from streams, they are found as large as the fist, and occasionally as large as a man's head. Thus near Prattville in Autauga county, there are many of these large pebbles, some of which have been used by the Indians for mortars in grinding their corn. One of these in the cabinet of the University of Alabama, is over nine inches in diameter.

As to material, the pebbles are all silicious, being in great part of quartz and its varieties, agate, hornstone, flint, jasper, etc., but especially in the northwestern part of the state, it is usual to find among the well rounded pebbles of quartz, others subangular and sometimes scarcely waterworn at all, of chert, and evidently derived from the chert with which the Subcarboniferous and Cambrian limestones of the Paleozoic formations are contaminated. Many of these chert pebbles contain impressions of the fossils of

the Subcarboniferous beds, especially the impressions of the stems of *crinoids*, but occasionally other forms such as *corals*, *brachiopods*, and *pentremites*. In other pebbles the oolitic structure is often beautifully shown, a character shared by the cherts both of Subcarboniferous and Silurian. Again we find in many of them the angular cavities left from the dissolving away of crystals of dolomite. This character was long considered by us as evidence of the derivation of the pebbles from the chert of the Knox Dolomite, in which such cavities are very common, but the same cavities have occasionally been noticed also in some of the Subcarboniferous cherts, so that they cannot be relied upon absolutely an index of the age. The great bulk if not all, of the fossiliferous pebbles can be referred to the Subcarboniferous formation.

In very many places small water-worn fragments of limonite are encountered among the pebbles. In very many of the chert pebbles we may notice in Alabama what Hilgard has described in Mississippi, viz., that they have undergone a process of decay by which they have acquired an earthy appearance, and adhere to the tongue, though still almost entirely silicious. In many parts of Lauderdale county, the bedded chert of the Subcarboniferous has undergone a similar change in place, by which it is converted into a mass of white pulverulent silica. In some cases, the chert beds will retain their original shape and in part their original appearance on the surface while within almost completely decayed, while on the other hand, some fragments of the chert show a nucleus of the original quality enveloped by these products of decay.

In Alabama the pebbles do not appear in any force north of the Tennessee river, nor in the immediate valley of the river south of it, till below the topographic feature known as the "Little Mountain;" then gravel beds of immense extent set in at once and continue thence indefinitely south-

ward. Along the course of the Bear Creeks we may find some of the most extensive beds of gravel in Alabama.

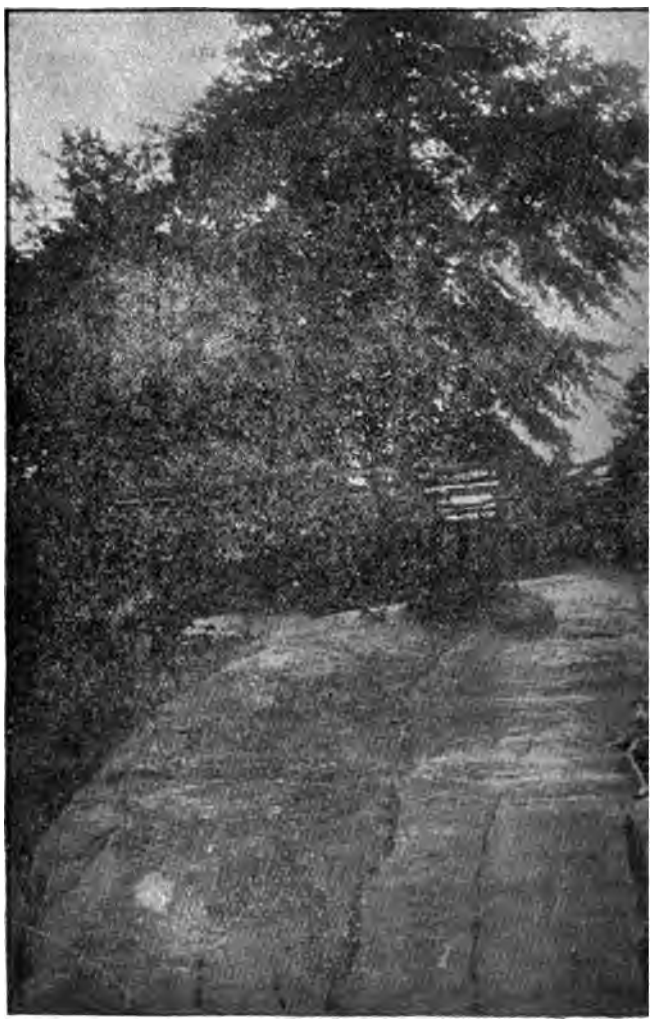
Of less general occurrence are the clays, which are found in rather isolated and limited masses. They vary in color from pure white, through pink and bluish to gray, and are generally quite plastic. In quantity they do not appear to be of any commercial importance. In the north western counties of the state there are some good beds of clay associated with the pebbles and loose sands covering the Paleozoic formations of that section, and these have in the past been considered of this age, but our recent investigations show that in most if not all cases they belong to the Tuscaloosa division of the Cretaceous, which in other respects also is exceedingly difficult at times to discriminate from the Lafayette.

The Chemical Effects of the Lafayette upon other Formations.—These have been summed up by Dr. Hilgard as follows: Lixiviation and Oxidation by the joint action of carbonic acid and oxygen; the action of silicious solutions; and that of ferruginous solutions. Of these agencies we wish to speak particularly of the effect of silicious solutions, which is exhibited not only upon the underlying formations, but also upon vegetable remains imbedded in the strata of the Lafayette. Everwhere we find trunks of trees silicified in such a way as to preserve perfectly the organic structure. In the hollows of such petrifactions it is not unusual to find a lining of small but perfect crystals of smoky quartz, and sometimes these crystals occur in loose spherical aggregates of crystals half an inch to an inch in diameter. The material of the silicified mass is usually a brownish hornstone, but it varies widely, being at one extreme a fibrous whitish substance that resembles asbestus.

In the south eastern part of the state especially it is the rule rather than the exception to find the Vicksburg limestone which constitutes the underlying terrane, completely

leached of its calcareous matter which has been replaced by silica, so that while there is not the slightest trace of effervescence with acids, this silicified rock holds all the characteristic shells of this horizon, themselves also completely silicified. That this alteration of the limestone is due to the overlying sands there can, I think, be very little doubt, but in all this region in Alabama and Georgia, the Lafayette itself is covered by a layer of sands of later date, (Ozark or Geneva sands,) and these may have contributed their share towards the silicification.

Genesis of the Formation.—Concerning the mode of deposition of the Lafayette we have two suggestions. The first, originating with Dr. Hilgard, attributes it to great floods of fresh water sweeping over the land from the northward, denuding the surface over which it flowed, taking up and redepositing further down the materials of the underlying terranes, so that the Lafayette very often has a close connection with these underlying strata. The waters found their way to the Gulf by numerous wide channels which are now marked by the great pebble streams, while in some cases the floods were sufficient to cover also the heights between adjacent drainage channels. In other words, according to Hilgard, the Lafayette is a great delta formation, or perhaps one might better say, it is a deposit from overloaded currents. On the other hand Mr. McGee conceives that at the time when the Lafayette materials were deposited, the coastal plain of Alabama as well as that of the whole United States up to New Jersey, was submerged to the extent of bringing the waters of the sea and Gulf up to the inland margin of these deposits; which was in general terms, up to the edge of the Paleozoic. At the same time the land was tilted seaward, thus stimulating the rivers to greater action both of erosion and transportation. The great volumes of sands and pebbles thus washed into the enlarged Mississippi Bay, came to rest orig-



TYPICAL EXPOSURE OF LAFAYETTE STRA

CHATTAHOOCHEE RIVER, BARBOUR COUNTY.

same materials constituting our third terraces will have to be similarly classed, for the gravel forms a part of the Mississippi river terrace, and caps the hills and covers the slopes at many different elevations beyond the river terrace, precisely as it does throughout the state of Alabama.

The great variability in the stratification and in the arrangement of the materials of the Lafayette, are shown forth in many of the sections given below in the county details to which the reader is referred.

In the frontispiece, Plate I, the unconformidable contact of the Lafayette with the Tuscaloosa is clearly shown. The top of the section is the usual red loam below which come the irregular strings of pebbles which rest upon the eroded surface of the Tuscaloosa strata which here have a very decided dip.

In Plate II also the irregular bedding of the Lafayette sands can be seen. The erosion trenches shown in the view are also quite characteristic.

Age of the Lafayette Formation.—Concerning the age of this formation, we know certainly that it lies between the Upper Miocene and those beds of undoubted Pleistocene age which we have described under the name of Second Terraces, equivalent without doubt to the Port Hudson of Dr. Hilgard in Mississippi, and Louisiana. If the phenomena of glaciation be taken as the criterion of the Pleistocene, then the Lafayette will probably have to be classed as pre-Pleistocene, since yellow gravel which has been considered as of the Lafayette age has been traced up to and underneath the oldest of the true Glacial deposits, and as yet the existence of materials of Glacial origin among the Lafayette beds seems not to have been proven beyond question. And further, the general appearance of the formation and the demonstrably great amount of erosion which it had suffered before the deposition of the undoubted Pleistocene beds,

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envious gravel beds like the sands farther south, cover and conceal the underlying clays. Not until nearing the M. & M. R. R., eastward, are any washes and exposures to be found. As in many other places the heads of such streams as these small rivers, lie in great flats and savannahs, more or less swampy.

The very fact of the ponds, in some places 15 to 20 miles eastward of the Tensaw, argues a want of underdrainage, which would exist if the great depth of Orange Sand continued.

It may be reasonably inferred, therefore, that the impervious blue-gray clays come nearest the surface. No washes and no wells are in this region to offer an explanation. Though there is a dreary region between the gravels and these ponds which can not be explained except as an exposure of the older clay. At Williams Station have been many wells dug and bored, but none of them penetrate deep into the gray clay. Water is abundant 50 to 60 feet in depth in sand and gravel.

Where the railroad crosses the eastern fork of Perdido is something greatly resembling Pontchartrain clay; the same appears at the ford of the creek two miles N. W. of Williams Station. It is possible and highly probable this is only a modified clay stratum of Orange Sand, for nothing else can be satisfactorily made out west of the Escambia creeks. On West Escambia, however, *i. e.* Big Escambia, near Flomaton (the Pensacola Junction) a deep cut in the M. & M. R. R. is more satisfactory. As we might expect, coming down from the highlands of the divide (Flomaton is put at 68 feet elevation), much of the Lafayette will have disappeared. What is left of it west of the West Escambia River and between the two Escambias, and between them and Conecuh, has much the appearance of old high terraces and benches mentioned west of Flomaton. At the cut, the deepest seen, there were about 20 feet of sand and gravel, covering 20 feet in deepest part, of stiff gray clay. Approaching Conecuh river the land rises to something more resembling the usual sand hills of the Orange Sand, but soon again sinks to a very decided terrace of Second Bottom. Upon this bench (in places said to be one mile wide) are built Pollard and Brewton.

On the east, or rather the south bank of Conecuh there is a narrow band of lowland subject to overflow but not marshy, down to which come magnificent sand hills—hypsometrically 100 feet and over above the river. Nothing then is exposed here of the underlying strata, though at the ferry below Pollard on the Milton road, there is clay of uncertain genesis. Deep borings for water along the Second Bottoms reveal thickness of it, of less than 30 ft., where the gray clay is reached. At Pollard, after passing the top formation, only 41 ft. (70 ft. in all) of the heavy clay were penetrated before water rose in quantity, a flowing well, having it was said force sufficient to raise the fountain 30 ft. above the surface. It is deserving of remark that this is locally

called sulphur water; and in all respects has the appearance, odor, and taste of the artesian wells of Biloxi and Scranton. The fine clay of the borings also, and that washed out with first running of the well are exactly similar; which we will come to hereafter when we reach the question of these clays underlying the Orange Sand. To continue with regard to these it is very evident that Orange Sand is exclusively the superficial terrane east of Conecuh into Florida southward almost to tidewater, and northward beyond Mayo's Creek and Silas Creek, on both sides of which the hills are high. In the beds of both these creeks, but low down, is a clay in which they have cut their runs, that is no doubt the same clay seen on the Escambia. Up Conecuh river however, not very far above the mouth of Silas creek, is Silas Bluff where Eocene limestone comes to the surface. Southeastward of this in the line of the strike, it may safely be said that Orange Sand permits nothing to be seen, before reaching Yellow river, nor then even, except as an inference at Lake View and vicinity, which has ponds and sinks arguing the near presence of lime rocks. A little further south-east however, in Florida on Shoal river, and on Pond creek or bayou, and not far south of the Alabama line, is a great bed of Miocene marl with shells Farther on there may be place to recur to this formation; for the present it is referred to what is necessary to be said of Orange Sand. Thus far no effort has been made to describe the Orange Sand (that is, in this paper.) It has been so often described and by so many authors; its general appearance and structure have been presumed.

However good any all these descriptions may be, they do not reach every phase of its Protean shapes. There is a region on Black Water and Yellow river, or in a word it may be said on the east and south side of Conecuh, where the general appearance changes; the general impressions of a stratified deposit fail; ferruginous sandstones and pipeclays seem to be no more; gravel so constant an attendant ceases to be found, or only the smallest beds and minutest forms. And more, that southern flow or dip of the stream which we may imagine it to have, as if still in motion by impelling floods, seems arrested here, and seldom can any more structure be perceived than in a sand-dune. What is perceptible seems to run from the direct course between the mountains and the sea. It is now flowingly southwestwardly towards the Pensacola embankment, as if a great stream had run over from the Georgia Miocene sands, to obliterate our later Tertiaries, and beat back the Gulf from the Florida coast. It is not uniform then, either in material or structure. It has not sprung from the same sources, nor been moulded by uniform forces. It is not of fluviatile birth, yet attendant upon our rivers, it may be expected to exhibit types peculiar to each, and in lines parallel to the great waterways. This almost symmetrical development in connection with the remains we have of the ancient river systems, stamps it as a unit in its genesis

and a unit in time, whatever the local diversity. Of the Alabama Orange Sand west of the Chattahoochee river and south of the Eocene calcareous formation (constituting comparatively a depression), it may be said that no formation has a more persistent continuity and unity than it. It may be clay, it may be sand, it may be gravel, it may be stratified or poorly so, or one or all these, yet the experienced observer can not remain long in doubt, or well mistake it for any other. The only hesitancy he can ever have is on the Mississippi river between it and the overlying Port Hudson and its analogues, as continued along the Alabama and Florida coasts. A mistake which could not far miss the mark, or lead to any very serious misleading consequences for both are of fresh water and analogous genesis, and differ mainly in the order or time of deposition If the Point Hudson, as represented in Alabama by Nannahubba* Second bottom, is attendant upon our principal streams as a coarser and earlier kind of Loess, it is not to be overlooked that the Orange Sand also attends at a more respectful distance the great rivers, occupying in greatest force the beds of those oldest waterways already sculptured out of the Marine Tertiary. The Nannahubba comes again to fill up the uneven removal of the Orange Sand, and of course largely uses the same material. In appearance Nannahubba is of even horizontal stratification, or wholly unstratified, or in other words, the layers of whatever material in themselves are without structure, or silty, or loamy; whilst the Orange Sand however deep the deposit exhibits the work of an ever changing current.

This much prefaced, we may expect to find on the west side of the main water way of Alabama a parallel to what we have traced on the east: and in fact we do. Mobile county with the southern half of Washington presents a perfect counterpart of Baldwin. Both are quasi peninsulas, separated by the broad bay of Mobile and its system of affluents; both are flanked by minor systems, the one by the Perdido on the east, the other by the Pascagoula on the west; both have corresponding elevations; Bay Minette on the M. & M. R. R. is put at 303 (279) feet. The new survey of the Mobile, Kansas City & Jackson R. R. has the divide between Mobile and Escatawpa rivers 258 feet, and Citronelle on the M. & O. 333 feet; both approach the Gulf very near at the south with steep declines covered thinly by the ill defined Biloxi sands just at the coast; and finally both consist of essentially the same sands, clays and gravels. The minor streams emptying into the Mobile Central system, generally rise from bold sand hill springs, and flow with a rapid current; those going into the lateral systems east and west have broad savannahs, galls and bayheads, for their sources, and move sluggishly the greater part of their course.

*This term we have sometimes used to designate the Second Bottom deposits, E. A. S.

In case of both, it is also evident that the deposits of the Orange Sand lie thinly at those broad savannahs and branchheads, over the older clays to be spoken of further on, and which at these points could not have suffered great degradation before the advent of the Orange Sand material; the elevation being nearly the same as at the high points where the sand and gravel farther south had renewed the surface. The line of survey of the Pensacola & Memphis R. R runs across these very flats showing on both sides an elevation a little over 300 feet.

The parallels in Mississippi are also remarkable; and having been more explored there with better opportunities, thither we must go for a better understanding of the Lafayette. Among other structural similarities or parallels, we may notice the deep light colored sands about the head waters of Leaf River, in Simpson, Smith and Covington counties of Mississippi; and those of Covington and eastern Escambia of Alabama, giving rise to Yellow River and Blackwater as already mentioned. Again Pearl River stands a parallel to the Chattahoochee, although the great ridges between the former and the Mississippi have no counterpart east of the latter, just as the great Father of Waters itself has no parallel on the continent. On the map it will be seen that the Mobile county ridge of the Orange Sand is narrower than that of Baldwin, and that the extreme southern point is not so elevated. There is allowed it, where Franklin creek near the Mississippi line leaves it to traverse the Pt. Hudson on its way to Escatawpa river, measured across to where Bayou La Batre washes its eastern foot, only seven miles. On the line of the Mobile & N. O. R. R. (L. & N.) from where it crosses the same Franklin creek (26 miles from Mobile), to deep cut at the descent of Fowl River valley is 12 miles. This R R. from Fowl River to Mobile has no more deep cuts in strata decidedly Orange Sand, though it skirts Cottage Hill through the junction of it with the stiff Nanahubba bench or Mobile Terrace. This more sandy foothill formation may be recognized along northward as the site of the fine vegetable gardens and "truck farms" which supply the city. There may be still some doubt as to the judgment of assigning these 12 miles of deep red cuts from Bayou Franklin to Fowl River to the Orange Sands, but after a close inspection of the deepest cuts at Grand Bay. and finding by the elevation of the hills, and continuity of the ridge from the north that the probabilities are strong against its being Pt. Hudson; that the creeks of the region of Franklin Bayou and Fernland creek (which ran north from a higher ground in a mile of the bay,) Bayou La Batre and the headwaters of Fowl River itself rise from springs in these hills; and finding the materials of the cuts are wholly inconsistent with the hypothesis, I think the assignment ought to stand. In the Port Hudson or Pontchartrain clays of Mississippi there are no springs of water; no creeks or branches

rise in it, though many run across it. The lower layers at these cuts in Mobile county are sandy and of a structure not seen anywhere in the Port Hudson. The upper layers having very much the appearance of a red loam might be thought belonging to the "brick-earth" silts of Tangipahoa, but I think not. In the silts there may be concretions and small nodules of iron ore, but the mass itself is very fine silicious material with little clay. At Grand Bay these upper layers 10 to 12 feet thick are argillaceous with visible grains of sand, and the iron lumps are not in small concretions of ore only, but in large blocks and masses of ferruginous sandstone. Having settled satisfactorily in my judgment that the upper layers at Grand Bay are also Orange Sand, there is no difficulty in assigning all the other cuts eastward to the same. Some of them exhibit finer, more silty material, but not more so than is often seen on the summit of Orange Sand ridges, and the continuity being unbroken there is no good reason for separating them stratigraphically. It is true, just as St. Elmo near which commenced some of the springs of Bayou La Batre, the level gall-berry flats have much the apperance of a Port Hudson surface; yet again such flats are not uncommon on the Orange Sand ridge farther north. At least the flats are not "Pine Meadow," such as lie so near to the west, for that would certainly indicate the latter clays. The wells at St. Elmo are 60 feet deep before getting water in the sands, a depth not at all uncommon in the Orange Sand. Excavations in this vicinity have not made it decisive whether the Orange Sand goes out to the sea or not; and whether it runs under the Second Terrace at the city or not. There was a great erosion of the formation before the Mobile terrace was laid down. As already mentioned under the former head, the Port Hudson is pierced through at Pritchard Station only three miles north of Mobile without revealing decidedly Orange Sand, yet water was gotten in white sand, and at Chickasa-Bogue bridge near line of the Mobile and Birmingham Railroad, the Second Bottom formation rested directly upon the old blue gray clays, which we will reach further on, under the name of the Grand Gulf. It is not probable that the deep gray clays suffered a very great erosion along this part of the ridge. The natural dip would bring them down almost to the level of this water on to the point where seen on Chickasa-Bogue twelve miles north of Mobile; the city has an elevation of only six feet. It is a fair inference therefore that the whole of the elevation at Waterworks and at Spring Hill set down at 205 feet is all Orange Sand, and gives the true thickness of the formation on this part of the ridge; a thickness by no means surprising when we shall come farther west, to well-borings which have pierced it in many places. In Mississippi from data carefully collected, Dr. Hilgard* assigns it a thickness from

*Geological History of the Gulf of Mexico, p. 9.

60 to 100 feet, overlying the Tertiary terranes, from which it had again in many places been partially taken away or wholly removed. The father south the less of this degradation has taken place, until over the Grand Gulf there was pretty generally this grand covering. It was natural and to be expected if this fine sketch of the History of the Gulf of Mexico approximates the truth, that in the descending period, these drifted materials should accumulate deepest at the edge of the ocean. This is certainly a rational hypothesis for its accumulation in such heaps upon the heights, which we know begin at Ft. Adams and run across eastward at least as far as Baldwin county, Ala., which might have marked the shore line at the end of the "Champlain" depression. In the Terrace period subsequent to bringing these points back to the present elevation, it was further to be expected that every removal and rearrangement of this material would only cause deeper accumulations at the edge of the retiring sea. Consequently it is no surprise to find the same author ascribing to it in places a depth of 200 feet.

With opportunities offered since and data now before us in the deep borings to be soon presented, it is no exaggeration at the overlap of the Port Hudson to ascribe to the Orange Sand a depth exceeding 300 feet.

The most unexpected results of recent investigation, are the extension, of the great Orange Sand hills to tide-water, as we have seen to be the case in Mobile and Baldwin counties. It will take somewhat from the singularity so surprising to one who has seen it in Mississippi only, to add that such extension does not stop at the bluffs on the Alabama side of Perdido Bay; it is strongly developed on the Florida side also. In fact, the ridges of this formation so high at Williams and Canoe stations, make on south to Pensacola. A little west of this city the Orange Sand approaches within a mile of the bay. So plain and remarkable is it that ordinary driven wells here, even out in the Bay, pierce through the tough blue brown clay of the Pt. Hudson equivalent, to inexhaustible heads of water in Orange Sand, and become flowing fountains.

The great beds of the Orange sand still continue on southward and eastward over the Miocene Marls until stopped by, or mingled with, the coarse sand formation of Pensacola Bay, Chattahoochee Bay and others not yet understood. One of last clear undoubted developments of it is at Orange Hill, 6 miles south of Chipley in Florida. South of that also in that vicinity runs east and west, "Setson's" ridge, evidently an old shore line, where our Lafayette once bade the Gulf be still. Further east has not been actually explored and reports are conflicting.

INTERPRETATION.

The correlation of these great deposits of sand and clay, considered by Mr. Tuomey "Alabama Drift" and by Dr. Hilgard as peculiarly developed in the trough of the Mississippi, calling them "Southern Drift," and more generally Orange Sand, has for a long time attracted the attention of geologists. Its genesis and homologues will not be discussed here. But it gives pleasure to make special reference to the papers of Mr. W. J. McGee of the U. S. Geol. Survey, recently published under head of "The Appomatox Formation," and "The Lafayette Formation." In the main we understand him as working out more fully the hypothesis of Mr. Tuomey, who was the first to trace this formation from its faint beginnings about Baltimore and Washington, (where he possibly confounded it with the more recently discovered and differentiated Columbian) through Richmond and Petersburg, Va. and Columbia, S. C., to Tuscaloosa, Ala. * * (2d Biennial Rep. p. 144 to 147.) That he thought it Drift need not create any confusion for us. Following this lead, we have continued to call it Orange Sand, with no special theory connected with the name. As to its age we do not think this clearly and definitely established. It certainly overlies all that we have seen of Tertiary formations in these Gulf States . It is above the Eocene as well as the Cretaceous in Alabama, and it is above the beds in Florida, on Appalachicola, Chipola and Shoal River undoubtedly Miocene, and above the Grand Gulf in all its phases, some of which are fossiliferous in Mississippi. But it sinks and disappears under our recent coastal sands below Pt. Clear and Grand Bay, and is undoubtedly deeply covered by the Port Hudson and the newer silts and gravels of the Loess of Mississippi. If it could be determined to what precise Epoch these belong, we could then approximate more satisfactorily the period of our Orange Sand. For these and other reasons we prefer to use the old well understood name which carries no theory with it, leaving the final discussion of its age and genesis, to a special occasion.

MIOCENE.

In Hilgard's Report on the Geology and Agriculture of Mississippi we find the first mention of a formation which follows next towards the southward, and consequently immediately overlies the Vicksburg orbitoidal limestone. This series of sandstones, sands and clays, Dr. Hilgard called the Grand Gulf from its best exposure along the Mississippi river.

In subsequent writings of Dr. Hilgard, this formation

has been frequently discussed, and it has awakened much interest among geologists from the difficulties experienced in assigning it to its proper position in the geological scale. The few organic remains which have been found in these strata are obscure plant impressions or casts of shells not identified and perhaps impossible to identify, and all that was certainly known about the formation was that it was younger than the Vicksburg limestone, which is the uppermost member of the Eocene or lower Tertiary. During the years 1890 to 1892, Mr. L. C. Johnson, at first under the auspices of the U. S. Geological Survey, and afterwards with the Geological Survey of Alabama, succeeded in fixing very definitely the geological position of the Grand Gulf, and discovered a new Tertiary formation overlying it, to which he has given the name Pascagoula, and which, together with the Grand Gulf has been classified as Miocene or middle Tertiary. Mr. Johnson also established the fact, until then only a matter of conjecture, that the strata of the Grand Gulf series took part in the formation of the substructure of Alabama and he has marked off the area of its surface outcrop in Washington, Monroe, Baldwin, Escambia, and Covington counties.

1. The Pascagoula.

The boring for an artesian well at Mobile, reached greenish blue clays containing estuarine fossils, *Gnathodon Johnsoni*, *Hydrobia Mobiliana*, among others, at a depth of six hundred and fifty feet (650.) Similar clays have also been observed on Chickasabogue and Cedar Creek, but so far as we know without determinable fossils. It is therefore to Mississippi on the one hand and to Florida on the other, that we have to turn for better exposures of the new formation.

In Mississippi fossils were first discovered in these clays by Mr. Johnson in 1890, a little north of Vernal P. O. on

Chickasawhay river in Greene county, and on Pascagoula or Leaf River as far north as Gwin's Ferry, and as far south as the junction of Leaf and Chickasawhay. But calcareous clays characteristic of the formation form numerous bluffs on Pascagoula, Chickasawhay, Leaf and Pearl rivers from Americus on the south to Adamsville above Leakville in Greene county, and to the northwest as far as Columbia on Pearl river in Marion county.

Near Leakeville on the Chickasawhay river a bluff exhibits, below the usual characteristic Second Bottom strata, about 20 feet of bluish clays, alternating with somewhat similar bluish clays with dark and lighter colored spots that effervesce with acids, and in many of which may be traced faint forms of fossil shells. Further down the river and down Pascagoula to the latitude of Americus are similar bluffs all showing the loose calcareous sands and the bluish green clays which characterize the formation. In Alabama the exposures are much less satisfactory, for on Escatawpa or Beaver creek no bluffs or deep washes could be discovered, but the streams flowing eastward into the Mobile river show more or less of the blue clays near their mouths. In these no fossils have yet been discovered and they are assigned to this formation merely from their geographical position and the character of the material.

The geological position of the strata of the Pascagoula horizon is established with a fair degree of certainty by the fossils above enumerated, and this is confirmed by the study of the microscopic forms found in the greenish blue sandy clays reached at the depth of 650 feet or more in the artesian boring at Mobile which also furnished the shells mentioned. Mr. K. M. Cunningham has carefully examined this material and from the slides prepared by him, Dr. Anthony Woodward has identified the following forms which he considers as of Miocene age.

Miocene Foraminifera Occurring in the "Greensand" from the Mobile Artesian Well.

Cristellaria crepidula, Fichtel & Moll. sp....	from	depth	of	700 ft.
Bulimina elegans, d'Orbigny, ...	"	"	"	735 ft.
" elegantissima, d'Orbigny, ...	"	"	"	700 ft.
Discorbina rosacea, d'Orbigny, sp.....	"	"	"	700–735 ft.
Moliolina seminulum, Linne, sp.	"	"	"	735 ft.
Nonionina depressula, Walker & Jacob, sp..	"	"	"	700–735 ft.
Rotalia beccarii, Linne, sp.....	"	"	"	700–735 ft.
" soldanii, d'Orbigny, ...	"	"	"	700–735 ft.

This greenish clay or green sand contains also great numbers of marine fossil diatoms completely pyritized or converted into iron pyrite. Among them Mr. Cunningham has identified the following genera; *Coscinodiscus*, *Actinoptychus*, *Pleurosigma*, *Navicula*, *Triceratium*, *Synedra*, and *Melosira*. The markings of these diatoms were so much obscured by the coating of pyrite as to make identification of the species difficult or impossible.

Fossil diatoms of the same genera as those above named, and in similar condition, i. e. converted into pyrite, have been dredged from the ship channel in Mobile Bay, from depths of 25 to 30 feet.

The following notes of Mr. L. C. Johnson though relating to Mississippi localities are yet of sufficient importance to us in connection with the new Miocene formation discovered by him, viz., the Pascagoula, as to merit a place in this report. The Pascagoula was at first considered as a marine or estuarine modification of the Grand Gulf, but has since been placed as a distinct formation.

Recent explorations have brought to light the fact, that the upper layers of the Grand Gulf, though retaining the same general color and appearance and manner of stratification are quite different really in material, and possibly in method of genesis. A portion of these south eastern layers have also been found to contain marine or rather

estuarine fossils: This alone must separate it from the great north western beds of fresh water quartzites and clayey sands. To what extent this separation must be made is not yet fully decided. Provisionally we will divide them by an imaginary line giving the new division a uniform breadth, of the greatest depth found upon Chicasawhay and Pascagoula rivers, where recognizable fossils were first discovered. In honor of one of them it will be called

The Pascagoula Formation.

On the Chicasawhay side of the line fossils have been seen a little north of Vernal post office. On Pascagoula or Leaf river side only as far north and west as Gwinn's ferry, and south as far as the junction of the two rivers. But the Calcareous clays characteristic of the Formation have numerous bluffs as far south as Americus, and northward nearly to Adamsville, a little above Leakesville in Green Co. On this side of the State of Mississippi the extent of surface is 36 miles.* Upon the Pearl river side it sets in near Columbia. But the heavy clays of the Pontchartrain extend up to the south bank of Abolochitto creek, and deep wells in that vicinity through gravel beds, are said to have reached fossils in an underlying gray clay. They can only be of this Pascagoula Phase.

On the Mississippi, as we might expect, the upper division of Grand Gulf has no exposure that it is possible to recognize. The character and structure of the materials as seen in Mississippi must be dwelt on somewhat, for it is by these marks we must recognize it eastward in Alabama. A section at McInnis' Ferry, Leaksville, is a good example of a nonfossiliferous bluff, of Pascagoula Clays.

a. Sec. of bluff at McInnis' Ferry, Leaksville, Green Co. Miss.

No. 1.	(Wanting here at the river), sandy soil beneath the town	4 to 6 ft.
No. 2.	Clay and sandy clay	5 to 10 ft.
No. 3.	Whitish and yellowish sand, stratified, thin seams of pipe clay and small gravel with cypress logs and stumps quite sound	10-15 ft.
No. 4.	Blue clay, firm	3 feet.
No. 5.	Very firm and tough seam of No. 4	1 foot.
No. 6.	Similar bluish clay, but with darker and lighter spots, which effervesce with acid, and in many of which may be traced a faint form of fossils	4 feet.
No. 7.	A firm layer of No. 6. Both covered with white efflorescence after rains	1 foot.
No. 8.	A compact sandy bluish clay, gray when dry, nicely stratified or laminated, easily traced under water, and forms the bed of the river	7 feet.

Total of this bluff to be ascribed to the Pascagoula, No's 4 to 8, 19 feet.

*(A part of this, however, we shall further on see, must belong to the next order sub-division.)

A bluff 6 miles above Leaksville, and near the Adamsville P. O., I did not see, but Col. McLain, who lives there, a well informed gentleman, represented it as one of the few places on the river, where it encroached upon the high pine hills of the eastern bank; the total height being 150 feet, of which more than 100 feet is Lafayette, the lower part being a firm compact laminated clay, and a grayish sand the same, in his opinion, as the laminated c ay of the river bed at McInnis' ferry, with more sandy material beneath it. The upper sands and clays abound in plates and nodules of ferruginous sandstone. This, from what I saw on the country road on the west side of the river in deep cut branches, not suspected at the time, and not until the actual discovery of fossils lower down, I am clearly of opinion is about the base of the Pascagoula. No such soft, loose sands, and laminated sandy clays exist in the true quarzitic Grand Gulf. As we will see farther on, the highly silicious clays of that are of a solid unlaminated structure, impervious to water hardening in the air, and jointed or breaking into rhomboidal lumps or fragments. Below Leaksville many bluffs occur. I did not visit all of them. The greater part of them are on the west or right bank and not easily accessible except by boat. The only feasible road near the river is on the left bank ("the river road"), and the only one traveled by wagons. A mile below the McInnis Ferry on the same side of the river, in fact a continuation of the same bluff, is Greens' Bluff : only of interest in connection with the upper one, to determine with more satisfaction the dip of the strata, which cannot be more than 6 or 8 feet to the mile, to the southwest.

Roberts Ferry and Bluff is 13 miles below Leaksville, and is in S. W. ¼ of S. E. ¼ of Sec. 15 T. 1, N. of R. 7, W. A continuation of it also on the right bank is Lawson's Bluff one mile. A branch runs down on the south end of the River Bluff, forming the graded road to the ferry. By means of it and several deep washes, the structure of the overlying second bottoms sands is well exposed.

b. Section of Bluff, Roberts' Ferry, Miss.

No. 1. Is the ordinary yellowish surface soil, not worthy the name of loam. (Second Bottoms).

No. 2. Is the clay of the subsoil, and true representative in these second bottoms of the Port Hudson.....1 foot to 6 feet.

No. 3. The real fossiliferous Second Bottom sands with sticks occasionally and leaves, not plenty at this bluff.....12 feet.

No. 4. Is the ferruginous layer, which always forms as a divide, between the older clay, and the newer sandy lignitic deposits.....½ to 1 ft.

No. 5. Is the Leaksville clay, or quite similar. Instead of the dark and whitish calcareous nodules, the spots are harder and ferruginous. Towards the upper end there

are four long streaks of such ferruginous clay sand almost stony. They are not interrupted parts of the same line, nor strata one above the other, but in *echelon* as it were. Except these spots the whole 15 feet seem nearly homogeneous.

No shells were seen in this bluff, but a mile or two above, on the same side, a high bank all clay, where logs are rolled into the river, raftsmen told me that some years ago when they began putting in logs at that point the upper part of the bank was covered with rotten white shells. Oyster shells were also reported to me as occurring in Pipkins Branch, on the east side and some four or five miles N. E. of Robert's Bluff on section 16, T. 1, R. 6. but I failed to find the place. From the timber and other superficial facies, I judged the subsoil of the extensive terrace on the east side to be calcareous, as far up as McLeod's old mill, on a considerable creek of the same name. Not far below this creek (on sec. B. T. 1, R. 6.), is a noted mineral spring. The sulphurous odor, and alkaline and chalybeate taste, are such as usually come from beneath Port Hudson when lying upon calcareous strata. A little below this spring on the bank of the small creek that flows from Vernal, I saw live oak trees, the first this far from the coast, which I regarded also as significant of marls beneath. Below Roberts' Ferry about 2 miles S. E. ½ mile long, on lot 5 of sec. 27, T. 1, N. of R. 7, west, is the low bank only seen at lowest water, known to raftsmen.

On White's creek, is a fine exhibition of the Robert's Bluff clay. The mill-dam is built of it and the excavations for earth expose about 15 feet of these unmistakable, sandy clays, covered here by a great thickness (about 40 feet) of sands and clays, of which I could not see enough to be satisfied whether to be regarded as all Lafayette, or partly Port Hudson, or Second Bottom. Here then as at the Roberts Bluff, there is evidence of a great removal of these clays before being covered by the Lafayette, which in its turn was removed to make room for the Second Bottoms. All which is still clearer at the McRae Bluff, 3 miles north of Plum Bluff on the right bank. This also consists of but two members: 30 to 40 feet of yellowish sands constituting a high terrace land a mile or two wide, between the hills and the river, and 20 to 30 feet of sandy blue gray clay, the counterpart of that at White's creek, 5 miles east across Pascagoula bottom. No more bluffs of this character could be heard of on the river. Below Plum Bluff, 4 or 5 miles, and 1½ or 2 miles above Americus. there is a landing called Carter's Bluff, though it is in the midst of flowed bottoms. The bank is not exceeding 12 feet high, but at the base are well exposed 3 or 4 feet of our blue gray clays; above is only sandy alluvium. I was attracted to the spot by hearing of an exposure of shells here. The rumor proved true, but the shells are only of an old Indian camp now buried under 2 to 3 feet of soil upon which are

growing the largest trees. All the shells (of which I obtained many fragments) were *unios*. The next bluff is below Americus and already mentioned. The base has a few feet, I think properly assignable to the Pascagoula and so at Dwyer's Ferry which I could not visit. (Hilgard Report, p. 154.) This gives, at the utmost, on the river where there was a severe removal of the Lafayette, an overlap of the Port Hudson upon the Pascagoula of only about 5 miles.

As we have said the Pascagoula formation has not yet been shown to occur east of Mobile, but there is of course reason for doubting that it continues eastward and merges into the more calcareous types of later Tertiary deposits of Florida. Mr. Johnson has spent much time in the Florida Miocene and has followed the outcrops of it from the typical locality at Alum Bluff westward, and his conclusion is that our Pascagoula is represented by the uppermost of the beds exposed at Alum Bluff. This subject is dealt with more at length below in connection with what is said concerning the equivalents of the Grand Gulf, and to that section the reader is referred.

2. The Grand Gulf.

According to Dr. Hilgard* who first described this formation, its materials are essentially clays and sandstones, the latter generally aluminous and soft, and of white, gray, and yellowish gray tints: the sand being very sharp. Beds of loose sand are unusual; but the clays are quite meagre, though the sand contained in them (as is the case in the sandstones) is usually quite fine. In Mississippi the sandstones seem to be confined to the northwestern portion of the outcrop where they are the prevalent material, and they are accordingly seen in bluffs along the Mississippi river at intervals all the way from Grand Gulf down to Fort Adams near the Louisiana line. In the eastern and southeastern parts of Mississippi the clays and clayey sands make up

*Geology and Agriculture of Mississippi, p. 147.

the entire formation. Mr. Johnson has given of recent years a good deal of time to the examination of the exposures of the Grand Gulf in Mississippi as well as in Alabama, and his observations go to show that while the sandstones and quartzites are most prevalent northwest of a line drawn from Raleigh in Smith county, Mississippi, to Fort Adams on the river, yet they are not confined to that area, for some of these quartzites are to be found as far east as St. Stephens, Alabama. Dr. Hilgard remarks upon the great scarcity of fossils in all parts of the Grand Gulf, but Mr. Johnson has discovered in beds of white pulverulent silica of this formation, in Jefferson county, Mississippi, a shell of *unio* and many perfect impressions of leaves, among them an elm not readily distinguished from the American elm of the present day.

In Alabama the sandstones as above mentioned occur, but they are not abundant. The prevailing material in the lower part of the formation as seen in this state, is a clayey sand or sandy joint clay of bluish, pink, purple, gray or creamy white colors. This clay has a tendency to break up into rhomboidal fragments. The vicinity of Healing Springs in Washington county is the best place to study the lower measures of the Grand Gulf as it appears in Alabama. About half a mile north of the Healing Springs hotel is the "Chalk Hill," an outcrop of gray indurated clayey sands mottled with ferruginous stains, in places however almost white. Two miles northeast of this, between the two branches of Sinta Bogue, another and similar outcrop, and still others between Mill creek and Brier creek, and a mile or two north of Koenton. Near Spring Bank Church in in the southeastern part of township 6, range 3 west, is a fine exposure of the indurated mudstones of this formation similar to those of the Chalk Hill above mentioned. Underneath these materials, the strata are sands and clays as

shown in section of a well near the School House at Healing Springs as follows:

a. Section of Grand Gulf Strata at Healing Springs.

1.	Unstratified sands or soil	3 feet.
2.	Mottled sandy clay	12 "
3.	Yellow sands with ochre and pipe clay	10 "
4.	Blue clayey sands with fetid mud	12 to 15 ft
5.	Hard compact sands, whitish or gray	8 to 10 ft
6.	Looser sands, coarser grained, whitish	8 feet.
	Total	58 feet.

Of the lowermost bed only eight feet were penetrated, because water was obtained in moderate quantity. The surface at the School House is fifty feet lower than the summit of the Chalk Hill.

Strata somewhat similar to these have been traced by Mr. Johnson as far south in Washington county as the head waters of Bilbo's creek.

Near the head waters of Bates' creek in the same county, are somewhat heavy clays of this formation, covered by ferruginous sandstone and conglomerate of the Lafayette, and, locally protected thereby from erosion, appearing in moderately high ridges. Wells dug into these Grand Gulf clays are generally very deep and the supply of water small. Consequently wherever practicable, and the people exercise good judgment, wells are dug in the Lafayette which, wherever it is as much as twenty feet thick, is pretty certain to furnish a good supply of soft water. The water obtained in the Grand Gulf clays or clayey sands, is always hard, of a peculiar flavor, disagreeable to those not accustomed to it, and said to contain salts of magnesia and iron, but no sulphur.

The upper strata of the Grand Gulf, occurring in typical exposures about Hattiesburg, Mississippi, according to the observations of Mr. Johnson, rarely contain any of the silicious joint clays and quartzitic sandstone which char-

acterize the preceding lower division, but they are prevalently clays or clay sands, with an abundance of plant remains in places. Many of these fragments become nuclei for the formation of nodules of hard ferruginous clay sands: in places also there is much of iron pyrites; and there are beds of leaves, logs, and stumps, scarcely changed enough to be called lignites. In structure these upper beds are more distinctly stratified and often even laminated, many of the layers being almost pure sand, but retaining still the bluish gray color. Springs are not uncommon coming from the sands, and the wells yield a moderate supply of generally inferior water.

The best exposures of the rocks of this part of the Grand Gulf are to be seen in Mississippi, and a short account of one or two of the characteristic outcrops there will be of service in our interpretation of the few Alabama outcrops which we are in position to describe.

On Chickasawhay river below Winchester in Wayne county, there is an exposure first described by Dr. Hilgard occurring on the plantation of Col. Sam Powe. In this there are some eight to ten feet thickness of clay and sands filled with roots and trunks of trees and impressions of leaves, all in good state of preservation, in many cases determinable. Dr. Hilgard has since been inclined to consider this an outcrop of the Second Bottom deposits, but Mr. Johnson after close examination considers the first interpretation of Dr. Hilgard the correct one, and especially so because of the occurrence of many similar beds with leaves and other vegetable remains observed by him on Leaf River about Augusta and elsewhere the age of which appears to be unquestionably Grand Gulf. Thus at Rawles Spring on Mineral creek in the northwestern part of Perry county, Mr. Johnson finds a great bed of leaves in perfect state of preservation, covered and enveloped by a thin deposit of very impervious clay. These leaves all appear to be of

modern species. On Leaf river near Augusta in Perry county at Carpenter's Bluff or "Coal Bluff" there are exposed below the strata assigned by Mr. Johnson to the Lafayette formation, some fifty feet thickness of gray sandy clays, and below them some fourteen or fifteen feet of blue mud or muck filled with leaves, fragments of wood and of logs half rotten.

In Washington county, Alabama, the joint clays and mudstones of the lower Grand Gulf have been traced as we have seen above down to the head waters of Little Bassett creek. The lower part of this county has the peculiar topography which we are disposed to ascribe to the presence of the clayey sands of the Grand Gulf just below the surface, though in this region none of the leaf beds have been observed. For many miles here the country is a succession of crawfishy pine flats with abundance of *Spartina* grass, stunted long leaf pines, a few black jack oaks also stunted, with gall berry bushes in spots, and thousands of *sarracenias* or pitcher plants. The gently undulating, smooth, grass covered surface reminds one of a well kept park, but the air of desolation implied in the stunted timber growth, the absence of all sign of human habitation for miles at a time, and the primitive character of the few that are encountered soon dispel this idea. The surface soil here is usually a yellowish sand with a clayey sand subsoil, which must be somewhat impervious, to explain the imperfectly drained hollows that are so characteristic. In the upper parts of Baldwin and almost as far south as Bay Minette, we find the very same characters of timber, surface and vegetation, and the same is true of the western and northwestern parts of Escambia. These impervious clay-sands are strongly characteristic of the upper strata of the Grand Gulf. The deep borings at Biloxi and Mobile and other places near the Gulf coast, show alternations of sand and clay for many feet below the strata which may reasonably be as-

signed to the Lafayette. The great development of the beds of Lafayette in the upper part of Mobile and the lower part of Washington, and of Baldwin also, interferes very much with the surface outcrops of the grand Grand Gulf rocks or clays except along the water courses.

In Escambia county there are some very fair exposures of the Grand Gulf strata, e. g. at the R. R. cut on the Repton branch not far above Flomaton, below a covering of Lafayette sands, and loams, there appear first some four or five feet of reddish mottled clays, then a sandy ledge two feet in thickness, and below that to the bottom of the cut, clays again. At the Big Cut west of Flomaton, below the Lafayette are some 20 feet of the clayey sands of the Grand Gulf. In neither locality were fossils to be observed, but about five miles south-west of Brewton at "Coal Bluff" in section 7 township 1, range 11 east, the following section is seen:

b. Section at Coal Bluff, or Conecuh River.

1. Thin alluvial soil	4 feet.
2. Old bluff covered with timber	16 "
3. Sandy clay with logs and leaves	2 "
4. Bed of lignite and leaves	2 "
5. Dark gray sands to water level	6–8 "

No fossils were discovered here except the leaves and other vegetable remains, though the character of the materials of stratum No. 5, in its lowest part, leads to the suspicion that at very low stages of the water, fossils similar to those found at Roberts may yet be discovered.

Lovelace's Mill at Roberts is on the headwaters of Silas creek, in S. 5, T. 1, R. 12. The wash-out at the waste way exposes a well leached bed of black sand containing innumerable impressions of Miocene shells.

Of these shells Dr. Wm. H. Dall has identified the following: *Cardium Chipolanum*, a *Cardita*, a *Lucina*, and a *Macoma*, the species of which were not identifiable. It is the opinion of Mr. Dall that this fossiliferous bed belongs to the

Chipola division as established in Florida, and of which further mention will be made below. Mr. Johnson who made the collection has recognized other genera among the shell, e. g. *Arca*, *Pectunculus*, *Crassatella*, *Cardium*, and *Turritella*. The succession of the strata will be seen in the subjoined:

c. Section at Lovelace's Mill, Roberts, Ala.

1. Surface materials brownish sands	6 feet.
2. Lignite with cross bedded sands	8 "
3. Cross bedded sands	7 "
4. Tough clay with wood fragments	3 "
5. Fossiliferous dark gray sands to water level	3–4 "

West of Roberts and a little over a mile distant, and just below the mouth of Silas creek, is the Silas Bluff on Conecuh river. Hypsometrically the lower strata are about 12 feet lower than the fossil bed at Lovelace's Mill. A profile section is as follows:

d. Section at Silas Bluff, on Conecuh River.

1. Third terrace	
3. Second terrace	6 feet.
3. Very tough blue clay	2 "
4. Stratified clay and sand, water-bearing	6 "
5. Whitish sandy clay, with streaks or stains of iron	4 "

No. 5 is evidently of easy erosion whilst wet or before ever dried; hence generally removed and its place filled by alluvial clays and sands for several miles, or up to the Eocene rocks of Tippet Shoals. One interest in this section is that the strata numbers 3 and 5, may be identified in overlaps to the north of this locality. No fossils were seen at this small exposure in No. 3, but it doubtless lies directly beneath the fossiliferous sands of Roberts, and being a tenacious clay, probably contains at least the casts of these shells in some places. No. 5 is of unknown thickness but is evidently identical with the more sandy forms of the Grand Gulf.

It occurs at the surface at Mr. N. B. Dixon's (S. 1, T. 2, R. 13) six miles further north and about 150 feet above the

river at that point. This will accord well with the dip approximated at other points, namely of about 25 feet to the mile. The materials of the outcrop at Dixon's are identical with those at the Chalk Hill, at Healing Springs, viz., whitish sandy clays and sandstone with red and purple ferruginous stains.

Another overlap near Murder creek sustains the same estimate; and it is more interesting still because the clay bed at that place, though high and dry, seems to be of the same texture and in other respects the same as No. 3 of the Silas Bluff section. It contains fossils of which one, *Venus latilyrata*, may be clearly made out, and more doubtfully a *Mactra congesta*.

Age of the Grand Gulf.—In these Alabama sections in the eastern part of Escambia county we see the very marked and unmistakable strata of the Grand Gulf series i. e. the mudstones and silicious clays and sandstones, constituting the lower members of the formation as it is exhibited in Alabama, (the Fort Adams or Ellisville phase of Johnson), passing below the fossiliferous beds corresponding to the Hattiesburg phase of Johnson, holding forms characteristic of the Chipola division of the Lower Miocene, thus fixing very definitely the geological position of these lower Grand Gulf beds, between the Vicksburg orbitoidal limestone of the Eocene, and the lower or Chipola division of the Miocene.

On the Chattahoochee river the Chattahoochee formation named by Mr. Langdon, occupies this same horizon, and probably represents the eastward extension of this lower member of the Grand Gulf. It may, perhaps, be well to review the subdivisions of the Miocene as shown along the Chattahoochee in order that the relations of our Alabama formations may be more clearly seen.

In the fall of 1889 Mr. D. W. Langdon while employed by the Alabama Survey upon an examination of the formations exhibited along the banks of the Chattahoochee river,

discovered that a series of calcareous rocks of Miocene age overlay the Orbitoidal limestone of the Vicksburg age, from a point some ten miles above Chattahoochee Landing down to Alum Bluff just above Bristol in Florida. To these strata he gave the name Chattahoochee, but subsequent examinations by the geologists of the U. S. Geological Survey, have led to a subdivision based upon important differences in the contained fossils, and the name Chattahoochee has been retained for the lowermost 50 feet or more of these beds which immediately overlie the Eocene limestone, and, as has lately been shown by Prof. Pumpelly, unconformably. Above the Chattahoochee limestone follow about fifteen feet or more of sandy clay containing a great variety as well as great numbers of fossils; this bed is exposed at the base of the Alum Bluff and elsewhere and has been named the Chipola marl. Above this are some 25 feet of sands, fossiliferous below and grading into the Chipola beds, but without fossils above except perhaps impressions of leaves. These are cross-bedded sands with streaks of clay traversing the lower half and in these clay beds are found the vegetable remains spoken of. The next overlying beds belong to the upper or Chesapeake division of the Miocene, the previously described beds being lower Miocene. This Chesapeake Miocene division is represented along the Chattahoochee by some 35 feet of bluish gray marl filled with fossils by which the identification is made certain and easy. Still above this and forming the uppermost of the Miocene so far as yet discriminated, are 25 feet or more, of a tough gray clay containing a few fragments of vegetable matters and some obscure traces of shells.* Mr. Johnson has traced these formations westward from the Chattahoochee river nearly up to the borders of Alabama, and the identity of the Roberts

*The latest and most accurate survey of these strata has recently been made by Messrs. Dall and Stanley-Brown, and the results given in the Bulletin of the Geological Society of America, Vol. 5, pp. 147–170. We have made use of this report in the preceeding notes.

exposure with the Chipola marl seems to be sufficiently well made out. Mr. Johnson has also discovered a locality at Oak Grove in Florida a few miles south of the Alabama line, where great numbers of well preserved shells have been obtained, and they have been identified by Mr. Dall as equivalent in position to the Alum Bluff Beds above described. The Pascagoula beds of Alabama and Mississippi have not as yet been seen further towards the east than Mobile, but in Mr. Dall's opinion the probabilities all point to their being equivalent to the aluminous beds of Alum Bluff overlying the Chesapeake marl. Thus in Alabama we find very satisfactory connections of the hitherto unclassifiable Grand Gulf of Mississippi, with the easily placed fossiliferous Miocene beds of Florida. The upper or clay sand and lignitic division of the Grand Gulf formation so characteristically seen about Hattiesburg in Mississippi and at Roberts in Alabama, and everywhere unmistakably recognized as a member of the Grand Gulf formation, becomes fossiliferous towards the east and proves to be of the age of the Chipola Miocene. The underlying division of the Grand Gulf, last seen at Mr. Dixon's near Mason in Escambia county, has thus far yielded no fossils by which it may be correlated with the Chattahoochee Miocene beds, yet its position is identical with that of the Chattahoochee Limestone of Mr. Langdon, and there is no room for any reasonable doubt about their identity in age. And here again we have an illustration of the tendency of some of the Eocene and most of the Miocene formations, which in Mississippi and western Alabama are of fresh water or estuarine origin, to assume towards the east more and more distinctively marine characters.

This correlation has been brought out almost solely through the Alabama Survey,* for Mr. Langdon in 1889

* The identification of the shells and the correlation by means of them of our Grand Gulf fossiliferous beds with those of the Chattahoochee River, we owe to the courtesy of Dr. Dall. As early as 1891

made the discovery of the Chattahoochee Miocene and gave it its proper place in the series; later work of the U. S. Geotogist has refined upon this classification by recognizing the subdivisions and correlating with other parts of the U. S. Then later, Mr. Johnson while working for our survey found the Chipola fossils at Roberts, in Escambia county by which the Grand Gulf was definitely placed as a member of the lower Miocene, and he afterwards followed this discovery into Florida, where at Oak Grove he discovered the marl beds with well preserved fossils which have only the more definitely and certainly confirmed this classification.

EOCENE.

Most of the observations upon the Eocene formations of the state as they occur along the Alabama and Tombigbee rivers, were made previous to 1886 and were first published in Bulletin No. 43 of the U. S. Geological Survey above referred to. Since 1886 the examinations of these formations have been carried across the state to the Georgia line, and some minor changes in the classification have been thought desirable.

THE ST. STEPHENS WHITE LIMESTONE.

As already stated, we include in this formation both the Vicksburg and the Jackson groups of Conrad, Hilgard, and others, as well as the Red Bluff group of Hilgard, if it is developed in Alabama. The recent very extensive collections of Mr. T. H. Aldrich have shown that a large number of species of shells are common to the Vicksburg and to the Jackson bed. Certain lithological and paleontological dif-

we had collected *stratigraphical* evidence sufficient to bring us to the conclusion that the Grand Gulf beds and the Chattahoochee Limestone occupied the same horrizon in our geological column, and the collections made later by Mr. Johnson have made this conclusion a certainty.

ferences may easily be observed in the different parts of this formation, as set forth below, but these differences do not, in our opinion, justify us in dividing a formation which, in Alabama, so clearly presents itself as a unit. The term White Limestone has been used by Professors Tuomey and Winchell and by other geologists as representing both of the above groups, though most of the writers on Alabama Tertiary geology have called attention to certain differences existing between the upper and the lower parts of the formation as exhibited at the bluff at St. Stephens.

The term, moreover, is popularly used to designate this whole series of limestone rocks throughout the region in which it occurs. As above stated, it is in this sense that we also wish to use it, and we do not intend to confine the term, as does Heilprin, to the lower 60 feet, which corresponds to the Jackson division.

The thickness of the White Limestone in Alabama we believe to be not less than 350 feet, and our estimates are based upon the following facts: About half a mile from the Claiborne bluff, on the road to Perdue Hill, White Limestone filled with *Orbitoides Mantelli* Mort. occurs at least 200 feet above the base of the argillaceous White Limestone (Jackson) which immediately overlies the Claiborne fossiliferous sands. At this locality, therefore, we have undoubtedly 200 feet of limestones belonging to this division of the Tertiary. At Salt Mountain, 150 feet of coral limestone overlies the uppermost of the beds with *Orbitoides Mantelli*, and this, added to the orbitoidal and argillaceous limestones seen at Claiborne, gives what we consider to be the maximum thickness of the White Limestone.

As regards the classification of the White Limestone in the Tertiary series, opinions vary. Conrad says:* "The Claiborne group I regard as newer Eocene, the Jackson as

*Geol. N. C., Vol. I, Appendix A, p. 25, 1875.

older Oligocene, and the Vicksburg group as newer Oligocene."

Heilprin* also puts the Vicksburg and the Jackson together as Oligocene, though elsewhere in the same volume he speaks of the Vicksburg alone as Oligocene and places the Jackson with the Eocene as its uppermost member.

The view of Conrad was at first adopted by us, but subsequently the study of extensive collections made by Mr. Aldrich at Jackson and Vicksburg, the finding by him of *Venericardia planicosta* in the uppermost beds of the White Limestone near Claiborne, and other circumstances have led us to think that there is no good reason for separating any part of our White Limestone from the Eocene, and we have no strata in Alabama which we regard as Oligocene.

It is to be remarked that nowhere in Alabama have any deposits yet been found comparable with the fossiliferous beds of Jackson and Vicksburg in Mississippi, as regards either the excellence of preservation or the number and variety of the fossils; for, with the exception of *Orbitoides Mantelli*, *Pecten perplanus* Mort., *Zeuglodon cetoides*, and a few others, fossils are comparatively rare in the Alabama White Limestone.

Divisions of the White Limestone.—The few forms, however, which do occur here appear to be generally restricted to a definite horizon, and we recognize in every locality of its occurrence two divisions of the White Limestone, and in one place three divisions, each distinguished by peculiarities in its lithological characters and in its fossils.

The *uppermost division*, 150 feet in thickness, has as yet been observed in one locality only, viz, at Salt Mountain at the Middle Salt Works in Clarke county. The rock here, is a hard, white limestone, composed in great measure of masses of corals partly silicified. Near the

*Contrib. to the Tert. Geol. and Pal. of the U. S., p. 33.

base of this rock there occur great numbers of the spines and plates of echinoderms *

The *middle division* of the White Limestone has a thickness of at least 140 feet. Lithologically it varies considerably, being in part a hard, crystalline limestone weathering into rough, irregularly shaped pieces, which have suggested the name "horsebone" rock, popularly used to designate it. Another variety is a soft, sometimes pulverulent mass of nearly pure carbonate of lime, which is everywhere quarried for building purposes. When fresh, this rock may easily be cut with an ax or a saw, but it hardens on exposure to the air and lasts for many years, in chimneys and pillars to houses. This part of the White Limestone contains as a characteristic fossil *Orbitoides Mantelli*, often in such numbers that the rock is little more than a mass of the disks of orbitoides packed in soft, white carbonate of lime. The orbitoides are most abundant in the upper two-thirds of this division, becoming less and less abundant below this.

The *lower division* of the White Limestone, about 60 feet in thickness, is in general terms a light colored, argillaceous limestone resembling the Rotten Limestone of the Cretaceous formation both in the character of the rock and in that of the soils to whith it gives rise on disintegration. It is traversed by thin bands of tolerably pure, white limestone and by beds of slightly calcareous clay, the latter often impregnated with gypsum. In places it is strongly glauconitic. This division contains a greater variety of fossils than either of the other two, though probably a smaller number. The fossils appear in general to be much more abundant in the upper half of the rock, where the more commonly occurring species are *Pecten perplanus* Mort., *Spondylus dumosus* Mort., *Ostrea cretacea* Mort., *Terebratula lachryma* Mort.,

*This rock, or series of rocks, has not been observed anywhere else in Alabama, and we must therefore consider it as of local occurrence only.

and sharks' teeth, and bones of *Zeuglodon cetoides*. This upper and most highly fossiliferous part holds calcareous clays which are strongly phosphatic and occasionally well filled with phosphatic or coprolitic nodules. The lower half of this division, while less fossiliferous than the preceding, has in nearly every locality examined, a bed near its base at least three feet in thickness holding vast numbers of *Scutella Lyelli* Con. This, which we have called the Scutella bed, has often served us as a guide in the study of this formation in the field, since it overlies by a few feet only the Claiborne fossiliferous sands.*

This lower division of the White Limestone has usually been considered the equivalent of the Jackson, and the overlying orbitoidal rock (middle division) the equivalent of the Vicksburg group of Mississippi, and there seems to be no reason to doubt the correctness of the identification. The uppermost division has been observed or recognized only at one locality (Salt Mountain), but it will probably be found to belong to the Vicksburg group.

Illustrative Sections.—The following sections (see Plate XIX) exhibit the characters of two phases of the White Limestone as they are exposed along the two rivers, and a third phase seen in the lower part of Clarke county between the rivers.

(*a*) About six miles south of Jackson, in Clarke county, at the Central Salt Works, I obtained in the summer of 1885 a section of the uppermost of the White Limestone rocks which overlie the orbitoidal rock. These rocks, which are seen in actual contact with the orbitoidal limestone, form the summit of the White Limestone formation in Alabama,

*The rocks of the Claiborne group are distinguished from those of the White Limestone by the presence of glauconite in large proportion, and this Scutella bed is the first of the ferruginous beds of the Tertiary. We are undecided whether this Scutella bed should go with the White Limestone or with the Claiborne, since the fossil is found in both formations.

so far, at least, as our observation goes. At this locality, Salt Creek flows at the base of a hill rising 150 feet above the water level and composed of limestone in which the only recognizable fossils are spines and plates of echinoderms and great masses of corals. These corals make up a very considerable proportion of the hill. A few hundred yards from the base of the hill a thickness of about twenty feet of the orbitoidal rock, such as is used in the vicinity for building purposes, is exposed, and in such position as to show unmistakably that it underlies the coral rock of the hill just mentioned, which has the local name of Salt Mountain. (See Plate XIX, Fig. 1.

(*b*) The bluff at Saint Stephens on the Tombigbee River (Plate III), about one hundred feet in height, exhibits both of the commonly occurring phases of the White Limestone, viz, the middle and lowermost. (See Plate XIX). The uppermost 70 feet of this bluff consists of the soft White Limestone, which is extensively quarried for building chimneys. *Orbitoides Mantelli* occurs throughout this rock, but is particularly abundant in the uppermost 20 or 30 feet. Below the orbitoidal rock to the water's edge the limestone is rather argillaceous and holds in places great numbers of *Spondylus* (*Plagiostoma*) *dumosus* and other fossils which are usually considered characteristic of the Jackson group. In this part of the bluff, Mr. D. W. Langdon, Jr., of the Alabama Geological Survey, in 1884 discovered phosphatic nodules and a phosphatic marl, a more detailed description of which will be found in another part of this Report. In this connection it may be proper to say that in the summer of 1885 we found that a phosphatic marl occurs in the lower or Jackson division of the White Limestone everywhere in Choctaw, Clarke, and Monroe counties.

(*c*) About half a mile above Saint Stephens Bluff, and in plain sight of it, is Gopher or Baker's Hill, where the actual contact of the limestones of Saint Stephens Bluff with the

ST. STEPHENS

:E RIVER.

ferruginous sands of the Claiborne formation may be clearly seen.

The following section of Baker's Hill should set forever at rest the question of the relative positions of the strata concerned (see Plate XIX, Fig. 3.)

Section at Baker's Hill, Tombigbee River.

1. Orbitoidal limestone forming summit of the hill. This limestone is the same as that forming the upper part of the Saint Stephens Bluff, half a mile distant.....20 to 30 feet.
2. Argillaceous limestone with *Pecten perplanus* Mort. and *Pecten Poulsoni* Mort. in its upper part and with hard ledges in lower part.....55 to 60 feet.
   This rock is the same as that at the base of Saint Stephens Bluff, but only 15 to 20 feet of it are to be seen above water at latter place.
3. Bed with *Scutella Lyelli* in great numbers, 1 foot seen, at other points.....3 feet.
4. Coarse grained, ferruginous sands, passing downwards into reddish ferruginous sands, with the characteristic fossils of the Claiborne sands, viz, *Melongena alveata* Con., *Crepidula lirata* Con., *Infundibulum trochiformis* Con., *Corbula Murchisoni* Lea, *Turritella lineata* Lea, *Cytherea æquorea* Con., *Oliva Alabamensis* Con., *Turbinella pyruloides* Con., *Turbinolia Maclurei* Lea, *Voluta Defranckii* Lea, *Astarte sulcata* Lea, &c.....15 to 18 feet.
5. Bluish green, glauconitic sands and clayey sands containing a *Flabellum* similar to that found at Claiborne and at Coffeeville ..... 8 to 10 feet.
6. Hard ledge at water's edge at upper end of bluff .....1 foot.

(*d*) During the summer of 1885 many localities were visited in Choctaw and Clarke Counties where the White Limestone and the Claiborne sands are to be seen in contact, so that there can be no possible doubt as to their relative position, unless we assume that the strata have been overturned, and of this there is not a shadow of proof. Some of the localities were also visited by Professor Tuomey and by Prof. A. Winchell, while some have not yet been referred to in any published document. These localities will be given below, under Claiborne group.

Professor Tuomey* says that the Buhrstone, after dipping below the surface in the upper part of Clarke County, emerges again at the Lower Salt Works, in the southern part of the county. Our visit to this place in 1883 confirmed this statement of Professor Tuomey, but there were many things observed in the distribution of the rocks in Clarke and Choctaw Counties which were difficult of explanation so long as we confined our attention to the banks of the rivers.

During several excursions by land through these counties previous to 1883 and again in the summer of 1885, the present writer was able to collect the data which prove that the basin in Clarke County, referred to by Professor Tuomey, is by no means a simple syncline, but includes several undulations, by which the Buhrstone rocks are again brought to the surface of the country at several points to the southward of the line where they first dip below it. It is by reason of these irregularities that the southernmost exposures of the Tertiary rocks along the rivers are not made by the uppermost rocks of the White Limestone series, but in the case of Choctaw Bluff, at least, by those of the Jackson or lower division of the White Limestone.

Section at Choctaw Bluff, Clarke County.

1. Lafayette pebbles and sand, capped with red loam.....20 feet.
2. Bluish clay ..... 5 feet.
3. Greenish clay ..... 5 feet.
4. White argillaceous limestone or indurated marl, containing many large specimens of *Ostrea Georgiana*, *Scutella Lyelli*, *Pecten Poulsoni*, many tubes of *Aspergillum* or allied genus, and obscure casts of other fossils ..... 5 feet

The bluish clay (No. 2) contained in many places lignitized or half lignitized stumps, while the underlying greenish clay contained no fossils. No. 2 is unquestionably a member of the Second Bottom or Terrace formation.

At Gainestown, a few miles above Choctaw Bluff, there is another exposure of the White Limestone. The principal

*First Bien. Rep. Geol. Ala., p. 150, 1850.

rock at this place is a heavy bedded, yellowish limestone with *Orbitoides Mantelli.* This rock has been quarried for building purposes, and several large blocks of it are to be seen on the river bank at Choctaw Bluff, whither they were carried during the war. The tubes of Aspergillum are also to be seen at several places near Gainestown, and some of the clays there hold a very considerable amount of gypsum crystals, as described by Mr. E. Q. Thornton,* who also says that the bones of Zeuglodon have been found a few miles from the Gainestown Landing. From these circumstances it appears that a part of the strata at Gainestown, it is of the Jackson horizon.

(*e*) From Marshall's Landing, some miles above Gainestown, up to Claiborne, the bluffs on both sides of the river give a very complete and almost uninterrupted section, with none of the irregularities noticed on the Tombigbee, since all the strata show a gentle southerly dip.

At Marshall's Landing, the upper part of the bluff consists of the orbitoidal limestone, the lower part, of the argillaceous limestone of Jackson age, and from this point up to the mouth of Cedar Creek the other beds of the Jackson series form the low bluffs of the river, from which a very good section has been made, as follows :

Section of White Limestone strata, Alabama River.

1. Orbitoidal White Limestone of the usual character.....10 feet.
2. White Limestone containing *Scutella Lyelli* in numbers..10 feet.
   This is the base of the Vicksburg or Orbitoidal Limestone, which, as we have seen at Claiborne, has a thickness of 140 feet, and at Salt Mountain has 150 feet of a coral limestone above it.
3. Effervescent or calcareous, joint clay, in two beds, each 5 or 6 feet in thickness, separated by 3 feet of soft, earthy White Limestone; below this a harder ledge of limestone, and then about 8 feet of blue clay, passing into a blue, calcareous clay or marl, making in all.....about 24 feet.
4. Earthy white limestone, resembling the Rotten Limestone of the Cretaceous formation .....about 25 feet.

*Second Bien. Rep. Geol. Ala., pp. 250–51, 1858.

(This limestone has at intervals of 3 or 4 feet, ledges of similar but harder material projecting slightly from the faces of the bluff. These ledges vary from one to three feet in thickness.

5. Scutella bed (*S. Lyelli*), consisting of 3 layers: (*a*) a limestone, with a few *Scutellas* (*S. Lyelli*), 1 foot; (*b*) a ferruginous sand filled with the same *Scutella*, 1 foot; (*c*) a white limestone bed similar to (*a*) and 1 foot thick.....3 feet.

Beneath this is a bed of coarse grained, ferruginous sand, extending down to the water.....1 or 2 feet.

This bed is seen at Rattlesnake Bluff, Claiborne.

These relations are shown in the section. (See Plate XIX, Fig. 4.)

(*f*) The upper part of the bluff at Claiborne is also composed of the argillaceous White Limestone of the Jackson age, and as we ascend the hill back of Claiborne, leading up to Perdue Hill (2 miles), the orbitoidal limestone appears in gullies and wherever the surface soil has been removed, up to an elevation of 90 or 100 feet above the top of the river bluff. This is precisely the position which the White Limestone occupies with reference to the Claiborne sands at Baker's Hill on the Tombigbee, as well as at other localities in Clarke County, referred to above. (See Plate XIX, Fig. 5.)

The White Limestone is the surface rock over a very considerable part of Choctaw, Washington, Clarke, Monroe, Conecuh, Covington, and Geneva Counties and the lower part of Dale and Henry. Where the lower or more argillaceous portion of it forms the surface, it gives rise, upon disintegration, to a limy soil, very similar to that of the Rotten Limestone of the Cretaceous group, but the topography is much more broken, justifying the name of Lime Hills, which I have given to this region in the Report of the Geological Survey of Alabama for 1881–'82. These Lime Hills may be followed from Choctaw and Washington Counties, without a break, into Mississippi, and there can be no doubt as to their identify with the Jackson prairies of Professor Hilgard.

It is in these Prairie Hills that the Zeuglodon bones are always found. Other commonly occurring fossils are *Pecten perplanus*, *Spondylus dumosus*, *Scutella Lyelli*, *Ostrea*, *Cretacea Mort*, and a *Cassis* similar to one occurring at Red Bluff in Mississippi.

In the chapter given by Mr. Langdon, will be found many details concerning the distribution of the surface outcrops of this formation eastward of the Alabama River to the Georgia line, and I have to add also a few observations made by myself in Henry, Dale, Geneva, Covington, and Escambia during the summer of 1891. In all these counties the underlying limestones of this formation are in great measure covered by thick beds of sand of the Lafayette and Ozark or Geneva series, and it is the rule to find the surface outcrops of the White Limestone to be more or less completely silicified. This seems to have been the result of the solutions derived from the overlying sands, and Loughridge speaks of the very general silicification of the limestone in the adjoining parts of Georgia.*

The line between the White Limestone and the underlying Claiborne near the northern boundary of Geneva with Dale bends northward, and crosses Henry near the central part of the county, though its crossing of the Chattahoochee River is below the mouth of Omussee creek. This is due to an undulation in all the Tertiary rocks of this section, and by it the White Limestone and the Claiborne are kept virtually at the surface to the Florida line, as will be seen below in the details of Geneva county.

East of Midland City the outcropping lower Vicksburg rocks are all silicified at the surface and do not effervesce with acids in the slightest degree; some of the rocks are of the nature of flint. Below the surface at varying depths, the rock is a soft pulverulent limestone of the normal type, as may be seen where it has been brought up in digging

*Report on Cotton Culture in Georgia. Tenth Census, Vol. V.

wells. Near the mouth of Omussee creek a mile or two below Columbia, the Vicksburg limestone may be seen in quantity, in low bluffs, from some of which the rock has been quarried for the purpose of burning to quicklime. In other places in the same locality the rock is thoroughly silicified, and in both kinds the shells of *Orbitoides Mantelli* are abundant and perfect in preservation. These limestones lie immediately above strata of calcareous sand with ledges of indurated calcareous clay of yellowish green tinge, and at the mouth of the creek is a small island capped with beds filled with shells of *Ostrea sellæformis*. These sands, clays and shell beds would therefore represent the Jackson and upper part of the Claiborne formations.

The Vicksburg rocks show along the Chattahoochee River from Omussee creek to below Gordon, but inland towards Geneva, their outcrops are rare, as the country is covered by deep beds of sand and loam. At places along the banks of Big Creek below the post office of that name, occasional outcrops of the orbitoidal rock may be seen. In the vicinity of Geneva, the Claiborne and Jackson strata are exposed along the banks of Pea River and Double Branches, and the Vicksburg strata occur only along the foot hills beyond the river plain. Four miles west of Geneva, these Vicksburg rocks show near the river in large masses, which are completely silicified. The lower beds of the White Limestone together with some of the underlying Claiborne strata are to be seen in the river banks at Early's Bridge not far from Elton P. O. On Flat creek between Elton and Martha limestone with *Scutella Lyelli*, and *Pecten perplanus* outcrop in the banks near the bridge. Between this and McDade's Pond we see no Vicksburg rock at the surface which is covered with sand, but the occurrence of ponds and limesinks shows that limestone is not far below. Near the confluence of Yellow River and Five Runs the White Limestone shows on both streams, and near the river, is a fine lime-

stone spring which supplies the pond at Watkins' Mill, S. 5; T. 1, R. 16 E.

(*g*) On Five Runs a mile or two above the confluence there is the following section:

Section at Bridge over Five Runs. Upper part of T. 1, R. 15.

1. Calcareous clay, white and blue but turning dark brown where mixed with vegetable matter and forming a regular "prairie" clay. The lower part of this contains many concretions that are strongly phosphatic.....15 ft.
2. Calcareous clay indurated, full of shells of *pecten perplanus*, and in the lower part with *Orbitoides Mantelli*..... 6 "
3. Whitish calcareous clayey rock with many pecten shells in the upper part. This rock is rather firm and compact and makes the immediate channel and bottom of the creek. Very few fossils in lower part.

This seems to represent the lower strata of the White Limestone, notwithstanding the presence of the Orbitoides.

At N. B. Dixon's in section 1, T. 2, R. 13, the Vicksburg rocks may be seen along the banks of Conecuh river, and in many ravines near the river, and along with the fossiliferous limestone are beds of whitish gypseous clays containing concretions of phosphate of lime, not however, in very great abundance. At the head of Mr. Dixon's mill pond there is a strong limestone spring with the characteristic clear blue water. At many points among the hills, or rather upon the elevated plain away from the river are limesinks, sometimes dry, sometimes filled with water. In this vicinity may be seen most of the varieties of the White Limestone, viz., hard limestone, with characteristic Vicksburg shells; soft white rock such as is everywhere used for making chimneys; dark gray to bluish gypseous clays; and concretionary formations in the lime rock itself. Overlying the White Limestone in the vicinity of Mason, are the sandstones and mud stones of the Grand Gulf formation, which has been traced thus far towards the east.

(*h*) At McGowan's Ferry over Conecuh, there is a good section of the Vicksburg limestone strata as follows;

Section at McGowan's Ferry, Escambia County.

1. Hard ledge of orbitoidal limestone.....8 feet.
2. Soft white or cream colored orbitoidal rock, (chimney rock) 4 "
3. Ledge formed by concretionary masses of the rock....1 to 2 "
4. Soft limestone like No. 2..... 6 "

At Brooklyn, on Sepulga River, the white chimney rock variety occurs and there is a well known cave, Turk's, not far from the town. From Brooklyn northwestward along the course of Bottle creek, the effects of the lime are to be seen everywhere in the soils, which are rendered very fertile by it. The divide between Bottle and Beaver creeks is sandy and the lime does not outcrop through the sands, but on going down towards Beaver creek the lime lands are again prevalent, as is also the case with the lowlands of Sandy creek. Beyond Evergreen, in the lowlands of Murder creek the same limy clay soils are found, which have made this region so well known in former days. The natural growth upon the soils which are thus marled by the lower strata of the White Limestone, consists of sweet gum, white oak, magnolia, water oak, short leaf pine, and *pinus glabra*, or spruce pine, with cedar, and the long moss. The basis of this class of soils is the red loam of the Lafayette formation, with which are mingled the residual matters from the decomposition of the White Limestone strata, especially the lower beds of the same. A belt of this land some ten or more miles in width and extending from the latitude of Burnt Corn down the drainage region of Murder creek below Evergreen, and thence over into the region of Beaver and Bottle creeks, makes the best farming land of Conecuh county. At least this was the case before the lands were exhausted by improvident cultivation. Westward from Bellville towards the Alabama River the country underlaid by the White Limestone is generally high and level, and the Tertiary rock is covered by the sands and loams of the Lafayette and gives evidence of its presence only by the limesinks and ponds

that occur here and there. North and northwest of Monroeville the limestone caps some of the hills making the divide between Limestone and Flat creeks, while in the channels and down the slopes of the creeks the underlying Claiborne strata are frequently exposed.

Throughout the greater part of Clarke county the White Limestone is kept near the surface by reason of undulations in the strata, and in many places it has been exposed by the washing away of the overlying Lafayette sands, so that there is no part of the state in which these strata are so widely distributed. The uplift which we have called the Hatchetigbee anticlinal, keeps these rocks near the surface over the eastern portion of the county, and over the southwestern parts of Choctaw and the adjacent parts of Mississippi on the other side of the anticlinal.

Useful materials:—The soft white or cream colored limestone filled with the shells of *Orbitoides Mantelli* is extensively quarried in this and adjacent states for building chimneys, and pillars of houses. The quarrying is usually done with an ax and with a saw since the stone when fresh is soft and easily cut. It is dressed into shape afterwards by means of a plane into blocks of suitable size and shape which are much larger than ordinary brick, or 4 by 6 by 12, or in some cases 4 by 6 by 18 inches. When not too much exposed to the weather, rain, and subsequent frost, this rock stands well, since after exposure it hardens and becomes much less pervious to water. In the southeastern counties where it is so generally silicified, it has the name of buhrstone and might perhaps be used for that purpose, though I have not seen any mill stones made of it. In the silicified condition it would make a very durable building stone, and is so used in the rough state, in pillars and chimneys.

The shell marls which are often quite strongly phosphatic would improve almost any of the soils in the vicinity of their

outcrops, for as a rule the surface over the White Limestone is sandy or slightly loamy.

A kind of fossil resin resembling coal in appearance, but of much lower specific gravity, has been observed in small quantity in the St. Stephens limestone at several points, e. g. near Suggsville, at "The Rocks" west of Grove Hill, and near Rescueville in Choctaw county. A specimen from the last named locality was analyzed by Dr. Phillips with results as below.

Fossil Resin. Rescueville, Choctaw Co.

Proximate analysis.	
Volatile matters	62.90
Fixed carbon	34.50
Ash	2.30
Moisture	.30
	100.00
Ultimate analysis.	
Carbon	54.47
Hydrogen	7.72
Oxygen, by difference	29.71
Nitrogen	.22
Sulphur	5.28
Ash	2.30
Moisture	.30
	100.000

A very similar substance occurs also in the white limestone at the base of the Tertiary formation, and analyses are given below of two specimens from that horizon.

2. The Claiborne.

The beds which in Alabama intervene between the base of the White Limestone and the top of the Lignitic division, and which are at least 450 feet in thickness, may be divided into two groups of very unequal thickness, which exhibit very marked differences in their lithological features and in

the relative abundance and variety, though perhaps not in the specific characters, of their fossil contents.

The upper group, 140 to 150 feet in thickness, constituting the *Claiborne beds proper*, consists of ferruginous sands, calcareous sands, and calcareous clays, generally glauconitic. These beds are mostly loose and incoherent, crumbling easily and giving rise to no marked topographic features in the region which they immediately underlie. This whole group is distinguished by the abundance and the variety of its fossils. Near the top of the series is the bed of ferruginous sand which has furnished the greater part of the celebrated Claiborne fossils. The calcareous sands underlying for 60 feet the ferruginous Claiborne sand above named are clearly marked by the great numbers of the shells of *Ostrea sellæformis* which they contain. Below these beds are glauconitic sands and clays holding a great variety of well preserved shells.

The lower group, about 300 feet thick, consists of silicious and aluminous sandstones and indurated clays, with occasional glauconite beds; all, except a few thin beds with marine shells, containing very little lime and, by comparison with the preceding group, very few fossils. These rocks are mostly hard and resistant and form some of the highest and most rugged hills in the southern part of the state. To this series of rocks Professor Tuomey* has given the name *Buhrstone*, and has pointed ont their identity with all the Buhrstone rocks of South Carolina and Georgia.

Prof. E. W. Hilgard† placed these two together under the head of the Claiborne group, distinguishing the upper and lower divisions as the Calcareous and the Silicious Claiborne strata, respectively. From the section given in Hilgard's Report,‡ it seems that the middle part of what we have called

* First Bien. Rep. Geol. Alab., p. 150, 1850.

† Rep. on Geol. and Agric. of Mississippi, pp. 108, 123, and 126, 1860.

‡ Rep. on Geol. and Agric. of Mississippi, pp. 126, 127, 1860.

the Claiborne series, containing the great numbers of *Ostrea selliformis*, are the beds of the Calcareous division, best developed in that state. The Siliceous Claiborne or Buhrstone strata are found in great thickness in Mississippi and present practically the same features as in Alabama. The rugged Buhrstone hills of Clarke, Lauderdale, Newton, Kemper, Neshoba, and Leake counties, in Mississippi, have their counterparts in Choctaw, Clarke, and Monroe counties in Alabama.

As already indicated above in our tabular presentation, we have made the following subdivisions of the Claiborne:

A. Calcareous facies.

B. Siliceous.

A. Calcareous.

General characters:—The lithologic and other characters of the Claiborne beds have been stated above in the most general terms. A few additional details will suffice to give a fair conception of the general features of the Claiborne formation. Near the top of the series we find a bed varying from 15 to 17 feet in thickness, which, at Claiborne, Gosport, Rattlesnake Bluff, and Baker's Bluff, is a reddish yellow, ferruginous sand, literally packed with the most beautifully preserved fossils. In many parts of Clarke and Monroe counties, where this bed has undergone less change from exposure to the atmospheric agencies, these sands are mixed with a very considerable proportion of glauconite, and the color is a very decided dark green, instead of reddish yellow. This bed we have called the Claiborne Fossiliferous Sand. Below it are some 60 feet of calcareous clays and calcareous sands, the former making the upper 25 feet, characterized by a bluish color, shading into light gray below. The calcareous sands make up the lower 35 feet, and they are of a light yellowish color. The whole of this 60 feet of strata, except perhaps some 10 feet of blue clay near the top, is distinguished from all the other beds of the Claiborne formation by the great numbers of shells of *Ostrea selliformis* Con.

which it holds. These shells are found more abundantly in the hard, sandy ledges which occur at intervals of a few feet through the whole thickness of these beds. This part of the Claiborne formation, contrary to the experience of Professor Winchell,† we find to be the most widely distributed of any. We have identified it within two miles of Nicholson's Store in Choctaw county; at several localities on Souilpa creek in the same county; at Coffeeville; near Old Clarkesville; at Claiborne; near Monroeville; and at several places on Limestone creek, in eastern Monroe county. It is described by Professor Hilgard ‡ as occurring on Falling creek, near Quitman, and on Suanlovey creek, west of Enterprise, in Clarke county, in Mississippi, and it has been observed by Mr. Johnson in Wahtubba Cut, 5 miles south-west of Enterprise, Miss. Below these *Ostræ sellæformis* beds we find at Claiborne and at Lisbon some 50 feet or more of sandy and clayey beds, in many cases strongly glauconitic, and holding a great number as well as a great variety of well preserved fossils.

Illustrative Sections.—Such are a few of the most obvious characters of the beds which we here wish to include in our Claiborne formation. The precise details of the structure and composition of these beds may be gathered from the sections which follow.

The rocks of the Claiborne formation proper occur at Claiborne, Gosport, and Rattlesnake Bluff, on the Alabama River, and at many other localities in that vicinity. They also occur on the Tombigbee River at Baker's Bluff (a short distance north of St. Stephens) at Coffeeville, and at very many points away from the rivers in Monroe, Clarke, Washington, and Choctaw counties. We give, at first, the occurrences along the two rivers.

* Rep. on Geol. and Agric. of Mississippi, pp. 118, 119, 121, 122, 123, 124, 125, 1860.

† Proc. Am. Ass. Adv. Sci., Vol. X, Part II, p. 86, 1856.

‡ Rep. on Geol. and Agric. of Mississippi, pp. 126, 127, 1860.

[redacted]

1. Drift. 2. White limestone. 3. *Scutella* l

CLAIBORNE BETWEEN UPPER

liferous sands. 5. *Ostrea sellæformis* beds.

ANDINGS, ALABAMA RIVER.

lying stratified rocks are discovered only where these loose materials have been removed. Between the upper landing and the ferry these lower strata of the bluff are more clearly exposed to view.

6. A band of light yellowish gray, calcareous sand, striped with a number of hard ledges of similar sandy material. This band is a very prominent part of the bluff, but is in many places, as above stated, much obscured by the fragments of the other beds which have rolled down from above.....about 35 feet.
7. A band of dark, bluish green color, consisting of clayey sands and clays passing downwards into a greensand bed 6 to 8 feet thick, which appears, however, above water only above the upper landing.....about 12 feet.

The upper part of this band, at the lower landing, appears only two or three feet above the low water mark, and it is consequently best seen farther up the river. Between the two landings these beds, where they are above water, are generally covered with debris. The second of the bands above named is the lower part of the Zeuglodon-bearing bed of this part of the state, which has generally been considered as of Jackson age. The third band is also probably a part of the Jackson limestone, but we are not sure that some of it, especially the lower five or six feet, should not be placed with the Claiborne division. At any rate the line between the Claiborne and the Jackson falls somewhere in this band (Plates IV and V.)

Given more in detail, the section of the Claiborne bluff is as follows:

Detailed section of Claiborne Bluff, Alabama River. (Plate XX, Fig. 3.)

1. Lafayette-like deposits, consisting of sand, pebbles, and red loam of variable thickness.....35 to 40 feet.
2. Argillaceous, white limestone, with grains of glauconite, very few fossils.....45 feet.
3. Scutella bed; light colored, calcareous materials, holding great numbers of *Scutella Lyelli* Con.....3 feet.
4. Coarse, ferruginous sand, with glauconite, fossiliferous, passing below into more calcareous material, which is indurated and

1. Drift. 2. White limestone. 3. *Scutella*

CLAIBORNE BETWEEN UPPER

Tertiary bluffs, whence it is deflected across the wide second bottom to strike then the opposite border. At Claiborne the river flows at the base of the southern Tertiary border of its ancient plain; next it turns across the plain and strikes the northern Tertiary bluff at Gosport; it is then deflected to strike the southern margin again at Rattlesnake Bluff.

The feature of the Claiborne bluff which first attracts the eye of the observer from a distance is the existence of nearly horizontal parallel stripes or bands which mark the limits of the different materials that make up the bluff. These bands, which are pretty well brought out in the views, are marked off approximately in the second vertical column of Plate XX, Fig. 3, and, if we neglect the minor details, they may be described as follows:

Section of the Claiborne Bluff, Alabama River.

1. A bed of very variable thickness, consisting of sand, pebbles and red loam, which forms the surface over a great part of the state. The average thickness of this bed along the bluff may be put at.....35 to 40 feet.
2. A band of White Limestone containing glauconite grains, forming vertical faces usually striped by thin projecting ledges, about 45 feet.
3. A band showing two very distinct parts, viz., an upper part, a bed holding great numbers of *Scutella Lyelli*, 3 feet thick; and a lower part, 6 feet thick, of coarse, ferruginous sands which are indurated at the base and form a very marked projecting ledge.....9 feet.
4. A band of very uniform appearance of reddish yellow or buff color, consisting of a mass of shells embedded in red sand. This is the celebrated Claiborne sand. It weathers very smoothly and is less projecting than the ledges above and below it .....15 to 17 feet.
5. A band of light gray, calcareous clay with a few sandy stripes and indurated ledges.....25 to 28 feet.

All these beds make up the nearly vertical part of the bluff near and between the two landings. Below these to the river level the slope is almost entirely covered by the loose fragments rolled down from above, so that the under-

lying stratified rocks are discovered only where these loose materials have been removed. Between the upper landing and the ferry these lower strata of the bluff are more clearly exposed to view.

6. A band of light yellowish gray, calcareous sand, striped with a number of hard ledges of similar sandy material. This band is a very prominent part of the bluff, but is in many places, as above stated, much obscured by the fragments of the other beds which have rolled down from above.....about 35 feet.
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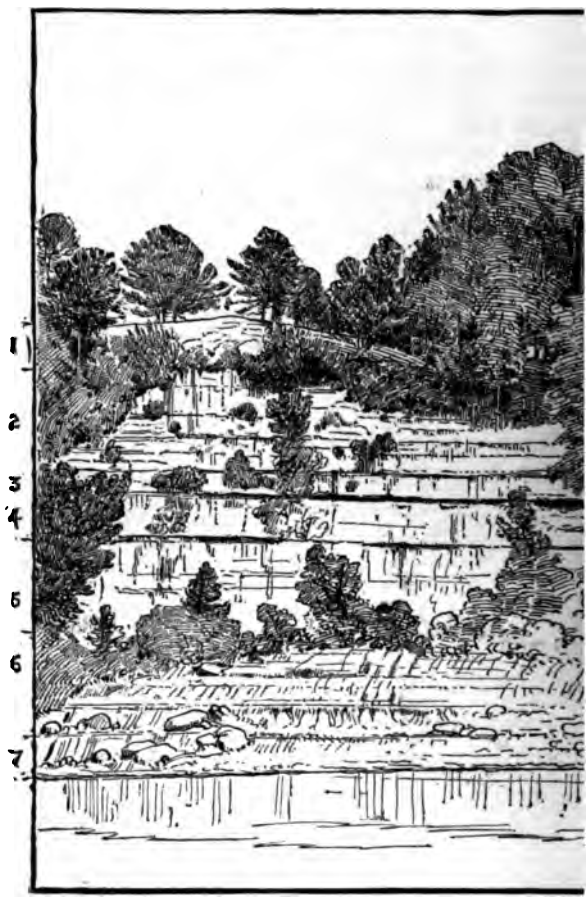


1. Red loam with pebbles and sand. 2. White limestone. 3. *Scutella*
(*O. sellæformis*). 6. C

acent ferruginous sands. 4. Claiborne sand. 5. Calcareous clay etc.
ue clay with greensand.

LABAVA RIVER.

projects from the face of the bluff. .....6 feet.

5. Ferruginous sand, holding vast numbers of comminuted as well as well preserved shells. Near the center of this there are, in places, thin bands of lignite, and along the ferry road the upper part of it is composed of laminated gray clays filled with leaf impressions. This is the source of the celebrated Claiborne fossils, and we shall call it the Claiborne Fossiliferous Sand. In many parts of Monroe and Clarke counties, where this bed is more protected, the material in which the shells are embedded is seen to be a greensand, while at the Claiborne bluff and vicinity, and at a bluff just above Saint Stephens, it is completely oxidized into a red, ferruginous sand. Thickness about Claiborne.....15 to 17 feet.
6. Bluish green, glanconitic, sandy marl, with *Ostrea sellæformis*, usually somewhat indurated above, and forming a hard projecting ledge.....3 to 4 feet.
7. Calcareous clay or clayey marl, of gray color when dry, but blue when wet. It contains a few badly preserved chalky fossils, *Bulla* and small *Turritellas*. This bed becomes sandier below, as well as glauconitic and highly fossiliferous, the principal shells being *Ostrea sellæformis* and a few *Pectens*. The clayey and sandy parts, together..... ....about 18 feet.
8. Light gray, calcareous clay, similar to the upper part of the preceding bed, with hard sandy ledges at top and bottom....7 feet.
9. Light yellowish gray, calcareous sands, with *Ostrea sellæformis* and *Pectens;* the lower half indurated and full of the moulds or casts of univalve shells..... .....5 feet.
10. Light yellowish gray, calcareous sands like those which make the upper half of bed No. 9. This bed has several hard projecting ledges of the same sandy material and contains a number of fossils; *Ostrea sellæformis*, fragments of *Scutella Lyelli*. *Scalpellum Eocense* Myer, *Pecten Deshayesii* Lea, &c. The sandy parts of this bed are loose, crumbling easily between the fingers. There are thin beds of more clayey texture, one of which, about the center of the stratum, holds a number of irregularly shaped, concretionary masses of clay. Near the base are one or two indulated ledges of glauconitic sand and shells of *Ostrea sellæformis*.....27 feet.
11. Layer of comminuted shells of *Ostrea sellæformis*, together with perfect shells of some other species embedded in glauconite or greensand.....3 feet.
12. Dark bluish black, sandy clay.....2 feet.
13. Bluish green, clayey sands with few fossils in the upper part, but becoming more clayey below and highly fossiliferous; *Venericardia planicosta*, *V. rotunda*, *Nucula magnifica*, *Arca rhomboi-*

della, Ostrea sellæformis, Voluta Sayana, Turritella lineata, T. bellifera Aldrich, besides species of *Natica, Corbula, Cytherea, Lucina*, &c. This bed averages 10 feet or more in thickness.

14. Dark green, sandy marl, glauconitic; grayish above, bluish below. This bed is sometimes badly weathered and of more brownish color. It holds a number of fossils, among which the most noticeable are a peculiar small form of *Venericardia planicosta* Lam. and large *Turritella Mortoni* Con. This bed, which is the lowest at Claiborne, may be seen between the upper landing and the ferry, and its exposure is from six to eight feet, according to the stage of the water.

(*b*) A few miles above Claiborne, near Lisbon Landing, we find the continuation of the Claiborne beds down to the top of the Buhrstone, and there is no doubt as to the geologic horizon of the Lisbon section, since the two lowermost beds of the Claiborne section appear at the top of the Lisbon bluff, the peculiar association of the shells making the identification easy and certain. In the following full section at Lisbon the bracketed numbers show the relations of the Lisbon beds to those of Claiborne, as indicated in Plate XX.

Section at Lisbon Bluff, Alabama River.

1. Sand and loam (Lafayette).....20 feet.
2. [18] Brown, sandy clays, difficult to describe more closely, as they are badly weathered and contain very few fossils.....10 feet.
3. [14] Dark brown, sandy clays, badly weathered, highly fossiliferous, containing the same shells as beds Nos. 13 and 14 at Claiborne, viz, the peculiar small variety of *Venericardia planicosta* Lam.: large *Turrttella Mortoni* Con., *Arca rhomboidella* Lea; *Lucina compressa* Lea, *Nucula magnifica* Con., *Turritella bellifera* (Aldrich), &c. This bed becomes more sandy below..8 to 12 ft.
4. [15] Hard projecting sandy ledge.....8 inches.
5. [16] Calcareous, clayey sands, light yellow when wet, nearly white when dry, glauconitic, forming smooth vertical bluff..6 to 8 ft.
6. [17] Coarse grained, sandy, glauconitic bed with comminuted shells and many finely preserved shells of uncommon occurrence.....8 feet.
7. [18] Light yellow, glauconitic sands capped with hard ledge..15 ft.
8. [19] Blue, glauconitic sands, probably the same as No. 7 above, but less completely oxidized, lowest of Claiborne strata....5 feet.

9. Bluish black clay, 8 feet actually seen, below which, to the water, 5 feet, all the strata are covered by fragments of the concretionary sandstone described below.

In the clay immediately below the glauconitic sands, No. 8, concretionary masses are formed, which resemble a tangled mass of roots or branches, exposed in high relief upon a plate or block of sandstone. These root-like concretions lie strewn upon the lower strata of the bluffs about Lisbon, and seem to be somewhat characteristic of this particular horizon, which we place at the very summit of the Buhrstone division, the Claiborne proper extending to and including No. 8 (19) of the above section.

The combined sections of the Claiborne Bluff and the Lisbon Bluff show the whole of the Claiborne formation, which, according to our division, extends from the White Limestone down to the top of the Buhrstone and includes about 140 feet of strata, of which 106 are to be seen at Claiborne, while the rest may be seen a few miles above Claiborne at Lisbon.

The fossiliferous sands (No. 5 of Claiborne section) have furnished the greater part of the beautiful Claiborne shells. The uppermost five or six feet of this bed are made up chiefly of the shells of *Cytherea æquorea* Con., *Pectunculus Broderipii* Lea, and *Crassatella alta* Con., 90 per cent. of the shells belonging to the first named species. The two feet next below contain not only many of the Cythereas but great numbers of other shells also, the most prominent of which are *Turritella lineata* Lea, *Rostellaria velata* Con., *Crepidula lirata* Con., *Turbinella pyruloides* Con., *Voluta Defranckii* Lea, *Monoceros armigerus* Con., *Melongena alveata* Con., *Ancillaria subglobosa* Con., &c.*

The strata below the Claiborne sands are much less fossiliferous and more sandy, *Ostrea sellæformis* being by far the

* Aware of the fact that most of these shells have synonyms, we have in most cases given our authority for the names used by us, leaving the question of priority to be decided hereafter.

most abundant shell down to the black clay stratum near the base of the bluff. The green sand beds at the base of the Claiborne bluff and at the top of the Lisbon bluff contain many of the rarer forms. The marl bed No. 6 of the Lisbon section promises to yield a rich harvest of novelties.

The collocated sections on Plate XX give the details of the preceding drawn to scale. For the sake of comparison we give on the same sheet the sections of Professor Tuomey† and of C. S. Hale.‡ Hale's No. 3 corresponds with our Nos. 14 and 15. His No. 4 and Tuomey's bed *b* are represented by our Nos. 12 and 13 and part perhaps of 11. Hales's beds 5 and 6 and Tuomey's *c* are our numbers 6 to 11, inclusive. The correspondence of the rest of the sections is easily seen.

Some of the more important exposures of the Claiborne beds elsewhere are the following:

(*c*) A few miles below Claiborne, at Gosport landing, there is substantially the same section as that at Claiborne.

(*d*) At Rattlesnake Bluff, below Gosport, there is the following section (see Plate XIX, Fig. 4):

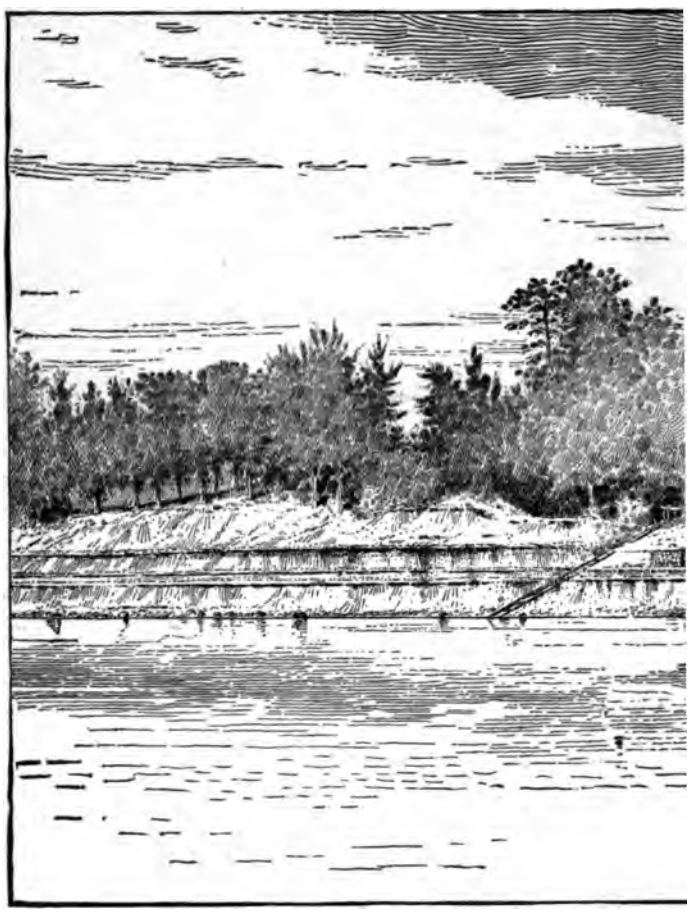
Section at Rattlesnake Bluff, Alabama River.

1. Ferruginous sands, becoming more calcareous below and terminating with a hard ledge..... 6 feet.
2. Claiborne fossiliferous sands..... 10 to 12 feet.
3. Calcareous clay or hard clay marl, with an indurated ledge in the middle..... 6 feet.
4. Clay marl, with *Ostrea sellæformis*, with four or five hard, projecting ledges, about..... 10 feet.
5. Greensand, indurated at top but softer below, extending down to the water, about..... 2 feet.

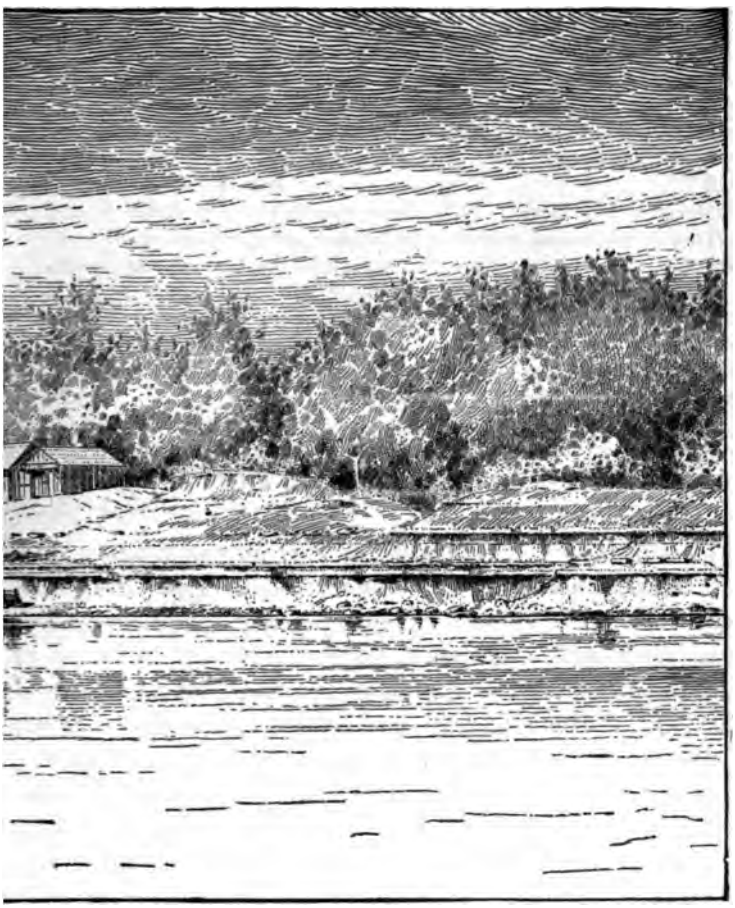
(*e*) On the Tombigbee river, half a mile above St. Stephens, there is a good exposure of the Claiborne sands, with some 10 to 12 feet of the next underlying beds, already given above in a section illustrating the White Limestone. (See Plate XIX, Fig. 3.)

† First Bien. Rep. Geol. Ala., p. 153, 1850.

‡ Geology of South Alabama, Am. Jour. Sci., 2d ser., Vol. VI, p. 354, Nov., 1848



COFFEEVILLE I



TOMBIGBEE RIVER.

(*f*) Still farther up the river, at Coffeeville landing, *Ostrea sellæformis* beds of the Claiborne profile form the river bluff, as may be seen from the following:

Section at Coffeeville Landing, Tombigbee River. (Plate XX, Fig. 4.)

1. Light yellowish sands, with *Ostrea sellæformis*, partly indurated, forming sandy ledge..... 3 feet.
2. Loose, yellowish, calcareous sands, with *Ostrea sellæformis*, indurated, sandy ledge at base... ..... 6 feet.
3. Loose, yellowish, gray, calcareous sands, highly fossiliferous, especially in lower part; *Ostrea sellæformis* the principal form; separated from next bed by sandy ledge..... 10 feet.
4. Bluish sandy clay or clayey sand, with *Ostrea sellæformis* and a flabellum; in two parts, separated by a hard ledge, the upper part 8 feet, the lower 3 or 4 feet, in all..... 12 feet.
5. A bed of glauconitic sand filled with shell fragments and perfect shells; *Ostrea sellæformis* Con, *Crassatella alta* Con., a flabellum; *Venericardia rotunda* Lea, *Corbula Murchisoni* Lea; *Pecten Deshayesii* Lea; *Arca rhomboidella* Lea, *Nucula magnifica* Con., &c.,..... 2 to 3 feet.
6. Dark bluish clays, nearly black, non-fossiliferous, breaking into cuboidal blocks... ..... 2 feet.
7. Dark greenish, clayey sand, like that near the base of the Claiborne Bluff, about 5 feet showing above the water.

The accompanying view of Coffeeville Landing (Plate VI) shows well the general character of the Claiborne beds. The lowest wood piles rest upon the black clays, No. 6, equivalent to No. 12 of the Claiborne Bluff section. The main fossil bearing bed, No. 5, is immediately over this, between it and the first (lowest) of the projecting ledges seen in the plate.

Hale states* that his bed No. 4 occurs also at Coffeeville with the same fossiliferous characters, and a comparison of the Claiborne Bluff section with the above shows very clearly the correspondence of the two. The bed No. 5 above is identical with No. 11 at Claiborne, except that it holds *Crassatella alta* and a few forms which we have not seen at the same horizon at Claiborne; but the underlying black clay (No. 6) is equivalent to No. 12, and the overlying bluish

*Am. Jour. Sci., 2d ser. Vol. VI, Nov., 1848.

and yellowish, fossiliferous sands (Nos. 1–4) are identical with Nos. 9 and 10 of our Claiborne Bluff section. These relations are shown in the sections, Plates XIX and XX.

There are no other exposures of the Claiborne beds along the two rivers, but in Choctaw, Washington, and Clarke counties, they are brought to the surface at many points around the borders of the Hatchetigbee anticlinal, as will be shown in detail in the section on the undulations of the Tertiary formation below. At this place a list of these localities so far as they have been observed by us will suffice. In many instances these Claiborne beds are seen in direct contact with the St. Stephens limestone.

(*g*) Thus, north of Bladen Springs, on descending the hill towards Souilpa creek, yellowish sands, with *Ostrea sellæformis*, the counterpart of our Nos. 9 and 10, are passed over along the road, while above them, near the top of the hill, is a fossiliferous bed holding forms common both to the Claiborne sands and to the marls at the base of the Claiborne Bluff.

(*h*) At the Barryton mill on Oaktuppah creek, three miles north-east of the village of Barryton, there is a bed of green sand filled with broken and perfect shells of *Ostrea sellæformis*, identical with No. 11 of our Claiborne Bluff section, and above it, as at Claiborne, a series of bluish and yellowish sands, with *Ostrea sellæformis*.

(*i*) About two miles northward from this mill the Claiborne fossiliferous sands occur, and at Womack's Hill, still farther northward, the White Limestone caps the hill.

(*j*) The yellow sands, with *Ostrea sellæformis*, are also seen at a mill on the headwaters of Oaktuppah creek, in the western part of Choctaw county, Sec. 8, T. 11 N., R. 4 W., and again within two miles of Nicholson's Store, on Billy's creek, where they are exposed at the base of a hill capped with the White Limestone. The same beds also occur in the

banks of Oaktuppah at many points below this probably all the way down to Barryton's Mill.

(*k*) Around the western end of the Hatchetigbee uplift we have observed numerous outcrops of the Claiborne. Thus on Push Cush creek in sections 17 and 18, T. 10, R. 4 W.; near Marion Carroll's, S. 21, T. 10, R. 4 W.; at Shoemaker's Mill, S. 2, T. 9, R. 4 W.; at Jordan's Mill, S. 13, T. 9 R. 4 W. In the piney woods between Isney and Bladen Springs are many limy clay spots—"piney woods prairies," which indicate the presence of the *Ostrea sellæformis* beds.

Thirteen miles west of Bladen Springs, D. W. Langdon, jr., of the Geological Survey of Alabama, saw in 1884 an outcrop of greenish, argillaceous sand, weathering red and containing a number of shells peculiar to the Claiborne sands, such as *Crepidula lirata*, *Corbula Alabamensis* Lea, and others commouly found in the Claiborne sand but not peculiar to it. This bed also was beneath the White Limestone.

(*l*) To the southward of the Hatchetigbee anticlinal several outcrops as follows: In the northern part of Washington county I saw, in 1882, an outcrop of marl containing *Turitella Mortoni* Con., *Ostrea sellæformis* Con., *Voluta Sayana* Con., &c., on Dry creek, S. 6, T. 8, R. 2 W., and again further south on the St. Stephens—Bladen Springs road near the Tony Rail place in S. 29, T. 8, R. 2 W. A short distance further south is the first outcrop of the St. Stephens limestone on the southern side of the anticlinal.

(*m*) In Clarke county, near the site of Old Clarkesville, in Sec. 23, T. 9 N., R. 2 E, there is seen in the bed of a branch a greensand containing all the peculiar shells of the Claiborne fossiliferous sands, and on the hills above, White Limestone containing bones of Zeuglodon.

(*n*) In Sec. 18, T. 9 N., R. 3 E., the same beds occur, and in the same relations to the White Limestone.

(*o*) On Stave creek, in Secs. 8 and 9 of Township 7 N., R. 2 E., and in other localities in the immediate vicinity, the

Claiborne sands, with all their easily recognizable and unmistakable shells, are at the water level in the creek banks, while the White Limestone outcrops on the hillsides hard by, with orbitoidal limestone on the summits.

(*p*) D. W. Langdon, in 1884, observed the Claiborne sands also nine and a half miles south of west of Grove Hill and fifteen miles east of Coffeeville, in both cases underlying the White Limestone. The locality on Stave creek was visited by Prof. A. Winchell* and the localities near Old Clarkesville were seen by Professor Tuomey† and by Professor Winchell‡ also.

(*q*) In Monroe county the yellow sands, with *Ostrea sellæformis*, occur in sections 25 and 34 of T. 7 N., R. 8 E., and in sections 19 and 30 of T. 7 N., R. 9 E., partly on the land of Mr. T. A. Rumbly.

(*r*) In Sec. 2, T. 7 N., R. 7 E., occur the yellow sands, with *Ostrea sellæformis*, as at Rumbly's, and in Sec. 12, T. 7 N., R. 7 E., the Claiborne greensand, with all the characteristic shells, occurs in the branches of the creeks, while the White Limestone occupies the summits of the hills.

Our observations correct a statement of Professor Winchell‖ that the calcareous beds underlying the Claiborne sands are not seen elsewhere.

Towards the west Mr. Langdon§ has followed these sandy *Ostrea sellæformis* beds into Mississippi as far as Suanlovey creek, near Garlandsville, in Newton county, a locality already recorded by Dr. Hilgard, and my own observations in 1871 already referred to, show that they may be followed to the bluff overlooking the Mississippi bottom. Recent reports record their occurrence through Louisiana, into Texas and to the bordess of Mexico.

*Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, pp. 84, 85, 1856.
†First Bien. Rep. Geol. Alabama, p. 149.
‡Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, p. 85, 1845.
‖Proc. Am. Assoc. Adv. Sci., Vol. X, Part II, page 86, 1856.
§On the Tertiaries of Mississippi and Alabama, Am. Jour. Sci., 3rd Series. Vol. XXXI, March, 1885.

Towards the east the Claiborne formation has been followed by Mr. Langdon through Monroe, Conecuh, central Covington, lower Coffee and Dale, and through the central parts of Henry to the Georgia line. Mr. Langdon gives detailed sections of the outcrops of this formation on Cane creek and Sepulga rivers in Conecuh, on Conecuh river at two or three points in Covington, on Choctawhatchee river below Newton in Dale, and at the mouth of Omussee creek in Henry. These details will be found in his paper to which the reader is referred. As we go eastward the character of the Claiborne beds changes somewhat, and we no longer find any traces of the ferruginous sands, the whole formation being represented by the lower portion of the formation or the *Ostrea sellæformis* beds. In thickness also there is a change of 145 feet along the Alabama to 75 on the Chattahoochee.

In the southeastern part of the state, by reason of undulations in the strata, the Claiborne, along with the other formations of the Tertiary, is kept near the surface over very considerable areas, and while we find the northern outcrop of the Claiborne running across the central part of Henry, and the lower parts of Dale and Coffee, yet it is above the low water level in Pea river as far south as Elton and probably still further, for at the confluence of Pea river with Choctawhatchee the Claiborne strata form the lower part of the river bed down to the Georgia line, as also up Double Branches at least five or six miles from Geneva.

In all this region these beds like the overlying St. Stephens limestone are very generally silicified, the principal shells being *Ostrea Johnsoni*, and *Ostrea sellæformis*. The descriptions of the counties named will give the details of these occurrences which need not be repeated here.

B. Buhrstone.

The fossils of this subdivision, as has already been suggested by Dr. Hilgard, do not appear to differ essentially from those of the calcareous Claiborne strata above described, yet the lithological character is so entirely different as fully to justify the division here made.

General Characters.—The rocks of the Buhrstone formation in Alabama, as well as in Mississippi, consist of aluminous and silicious materials, partly glauconitic, and in places interstratified with thin beds of greensand. The chief varieties of these rocks, in the order of their relative abundance, are the following:

1. Gray, aluminous sandstone, often glauconitic, with numerous galls or concretions of pure whitish clay and traversed throughout with streaks of yellowish, hydrated oxide of iron. In this rock are occasionally found impressions of shells. In the upper part of the formation, upon the surfaces of this sandstone, irregularly branching, cylindrical elevations of slightly harder texture, but apparently of similar composition, are sometimes seen. These ridges have in some cases the appearance of being organic remains (fucoidal), but are more probably concretionary. These are best seen at Lisbon Landing on the Alabama river, and west of Bladen Springs, in Choctaw county, and at other points along the southern line of this formation.

2. Indurated, white clay, forming a rock, which is, however, quite light and easily broken. This indurated clay has joint planes approximately at right angles to one another, the planes of separation being mostly stained red or yellow with hydrated ferric oxide. Fragments of this claystone worn into rounded pebbles are of common occurrence in most of the creeks and branches flowing through the Buhrstone hills, both in Alabama and in Mississippi. The claystones are often silicious.

Some of the lighter portions of this so called "clay" have been subjected to microscopic analysis by Mr. K. M. Cunningham, who finds it in great part made up of the silicious shells of *marine diatoms*, *radiolaria*, and *foraminifera*, thus being rather of the nature of tripoli or diatomaceous earth

than of a true clay. To this light silicious rock, the name "chalk" is very commonly applied by the people.

3. Hard, coarse grained, glauconitic sandstone.

4. Hard, yellowish, silicious, or aluminous sandstone, streaked with a darker shade of yellow.

5. A white, silicious rock, almost a quartzite, varied by spots of leaden gray color. This rock has often furnished the material for Indian lance and arrow heads. It occurs near the base of the series, associated with a hard, silicious sandstone.

The prevailing color of the rocks of this formation is light gray, often nearly white, and, on account of their hardness and resistance to decay, the country which they make is very broken and rugged. The high and often precipitous hills of the Buhrstone are usually called mountains in Clarke, Monroe and Choctaw counties, in this state, and in northeastern Clarke, Lauderdale, Newton and Neshoba counties, in Mississippi. The soil, where it is derived from these rocks, is, of course, poor, and mostly timbered with long leaf pine, and the country is generally very sparsely settled.

It is impossible as yet to give with absolute certainty the thickness of this division of the Tertiary. During the summer of 1885, I measured with the aneroid barometer at one locality, near McCarthy's Ferry, in Choctaw county, 270 feet of Buhrstone rocks, and, as this section did not include the uppermost beds of the formation, we are safe in placing 300 feet as the minimum thickness. I am strongly inclined to the opinion that the real thickness, in some cases, will rise to 400 feet. In the section we give the lower limit, 300 feet.

In general, the uppermost beds (fifteen to twenty feet) are composed of silicious joint clays,* which, when indurated, form tolerably hard rocks. Near the base of the formation similar clays or claystones are usually seen. In many

*These include the diatomaceous materials above mentioned.

places, there is a bed several feet in thickness of a hard, silicious, or flinty sandstone, almost a quartzite, just at the base of the Buhrstone. I have noticed this rock a few miles north of Bladen Springs, also near McCarthy's Ferry, and south of Pushmataha, in Choctaw county. In Choctaw and Clarke counties it is not unusual to find spear or arrow heads made of this material, which is easily recognized. The great bulk of the Buhrstone, as already said above, consists of aluminous sandstones.

Inasmuch as we have not yet been able to point out any characteristic distinction, based upon organic remains, between the Buhrstone and the Lignitic, we have thought it best to draw the line between them upon lithologic grounds, and our justification in this course is found in the following considerations: In the strata which we have called Lignitic, the material, as compared with that of the Buhrstone, is more sandy and calcareous and at the same time more fossiliferous. The shells in many cases are decayed and the calcareous matter of the same often appears to have been leached out and diffused through the surrounding sands, occasionally cementing them together and forming calcareous sandstone. These sandstone beds always show a tendency to weather into rounded, bowlder-like masses, which project from the faces of the bluff or, broken off, roll down, forming a talus. When broken open, these bowlders usually show a nucleus of thoroughly decayed shells or of ferruginous, lignitic matter.

A ledge of calcareous sandstone of this kind is found about twenty or thirty feet below the lowermost of the aluminous rocks, which we consider as characteristic of the Buhrstone, and similar calcareous sandstones weathering into bowlders occur at intervals throughout the underlying lignitic strata.

The aluminous rocks we assign to the Buhrstone, while the sandy rocks, with the intercalated beds of calcareous matter, we place with the Lignitic.*

This division based upon lithologic characters can be consistently carried out in Alabama, at least in the region contiguous to the two rivers, since the indurated clays and aluminous sandstones of the Buhrstone are in general easily distinguished from any of the other strata of the Tertiary formation. None of the beds of the underlying Lignitic have even a remote resemblance to the Buhrstone rocks, except certain indurated clays which overlie the *Gryphœa thirsœ* beds in the Grampian Hills of Wilcox county and their prolongation into Butler county. Even in this case the distinction between the two can readily be discovered, as the indurated clays of the Lignitic are, in some of the beds, quite full of shell casts, principally Turritellas and Cythereas and the material itself, upon close examination, does not so strongly resemble the Buhrstone as upon first sight appears. Then the circumstances that these lignitic claystones lie over 300 feet below the Buhrstone, are by no means so thick, and are in most, if not all, cases in immediate contact with the *Gryphœa thirsœ* beds greatly diminish the chance of any confusion between the two series.

Sections.—On the Alabama River the uppermost of the Buhrstone beds are well exposed at Lisbon Landing, and the lowermost, a short distance above Hamilton's, whence they extend across Clarke county westward or northwestward to White Bluff and McCarthy's Ferry and thence in a northwesterly direction across Choctaw county, just south of Butler. On the eastern side of the Alabama River they appear in the hills south of Bell's Landing, and across

*The uppermost of the strata thus classed with the Lignitic, viz., the Hatchetigbee, appear in their fossil contents to be rather more closely allied with the Claiborne and may hereafter be placed with the Buhrstone on that account.

Monroe county north of Kempville and south of Turnbull, turning a little to the northward in the eastern part of the county. To the eastward they may be seen again near Ozark, in Dale county, and near Abbeville, in Henry, county.

In general we have not attempted in the following sections to give the exact sequence of the different materials which form the Buhrstone beds. In most cases they are merely alternations of indurated clays, with aluminous sandstones of varying degrees of hardness. While in the extremes of pure clay and almost pure quartz the materials of this formation differ widely, the formation as a whole leaves upon the mind of the observer a lively impression of the uniformity in the lithological structure and general appearance of its constituent strata.

Although the best natural sections of the Buhrstone are perhaps to be found in the hills away from the rivers, we shall here describe only the exposures along the banks or in the immediate vicinity of the two water courses. The sections on the Alabama River are as follows:

(*a*) *Section at Lisbon Landing, Alabama River.* (*Plate XXI, Fig. 1.*)

1. Yellowish, sandy marl, lowermost of the Claiborne beds..20 feet.
2. Bluish Black clay, massive, jointed or breaking into cuboidal blocks, 8 feet seen, but to the water's edge..about 15 to 20 feet.

Immediately beneath the sands which form the lowermost beds of the Claiborne formation in this section concretions are formed which resemble a mass of tangled and matted roots. Blocks of sandstone with these concretions cover all the lower part of the section at Lisbon and they seem to be more or less characteristic of the uppermost beds of the Buhrstone.

(*b*) At Hamilton's Landing, 6 miles above Lisbon, is an exposure of 75 to 80 feet of light colored, indurated

clays or clayey sandstones with two or three indurated, projecting ledges, all characteristic Buhrstone rocks. (See Plate XXI, Fig. 2.)

The positions of the outcrops of the Buhrstone rocks on the Tombigbee River present apparent anomalies which at the time of our visit in 1883, we could not explain. The later observations, made by myself in 1885 have cleared up many of the obscurities, and the structure of the two counties of Clarke and Choctaw in its main features is pretty definitely made out. As stated above, the regular line of outcrop of the Buhrstone rocks extends from near Hamilton's Landing, on the Alabama, across to the Tombigbee at White's Bluff and McCarthy's Ferry. At both these localities we have very good sections of the lower beds of the formation.

(*c*) At White Bluff there is a clear exposure of these rocks in a cliff of about 115 feet. They are light colored, aluminous rocks, which, however, could not be closely examined because of the precipitous nature of the bluff. (See Plate XXI, Fig. 4.)

(*d*) At McCarthy's Ferry the immediate bluff of the river is made of the clays which underlie the Buhrstone, but on the hills just back of the river we get a section of nearly 300 feet of Buhrstone rocks. (See Plate XXI, Fig. 3.)

(*e*) Down the river from these localities the Buhrstone rocks dip beneath the surface, the overlying Claiborne beds forming the river banks, as at Coffeeville, &c., already mentioned, but just south of Coffeeville, at Hatchetigbee Bluff, the Buhrstone is again seen, and the lowermost beds at that, as shown in the section (see Plate XXI, Fig. 5.) The exposures at White Bluff and at the Hatchetigbee Bluff both show the contact of the light colored claystones with with the underlying sandy clays, &c., of the Lignitic, but at the former locality all except the uppermost 20 feet

or so of the Lignitic are obscured by land slips and rubbish of all sorts. These sections will be given in detail under the next heading.

(*f*) Still farther down the Tombigbee River these rocks sink again beneath the surface, for at St. Stephens, and just above, the Claiborne sands and the overlying White Limestone make the river bluffs, as before stated. At the lower Salt Works, however, we have the Buhrstone rising again to the surface, as described by Professor Tuomey,* During the summer of 1885 I ascertained that these rocks appear at the surface at an intermediate point, viz., near Jackson. The lower Salt Works are situated near the center of T. 5 N., R. 2 E., and the rocks exposed along the road which ascends the hill just south of the works are as follows:

Section at the Lower Salt Works, Clarke County.

1. Orbitoidal limestone forming the upper part of the hill, thickness not determined.
2. Between the orbitoidal rock and the topmost bed of the continuous section below given there is a space in which the rocks are coverd with soil, undetermined thickness.
3. Argillaceous White Limestone or clayey marl, with several indurated ledges of similar material.....about 18 to 20 feet.
4. A coarse grained, ferruginous sand, with harder ledge at base and above. The bed, as well as the harder portions, contains fossils, the most conspicuous of which are *Scutella Lyelli* and *Pecten perplanus*. This bed is strongly glauconitic near the base, about 9 feet.
5. Greenish clay passing at bottom into a ledge of hard claystone, the first of the Buhrstone formation .....3 feet.
6. Aluminous sandstones or indurated claystones of the usual Buhrstone character to the base of the hill.....16 feet or more.

About half way down the hill there is a bed of greensand holding a good many fossils.

That which most strikes the observer in this section is the absence of the sands and marls of the Claiborne formation. The glauconitic sands with *Scutella Lyelli* and *Pecten perplanus*, supposed to be of Jackson age, immediately

*First Bien. Rep. Geol. of Ala. p. 150, 1850.

overlie the greenish clays of the Buhrstone, while at Claiborne the two are separated by at least 130 or 140 feet of other strata.

Professor Tuomey* called attention to the fact that the Buhrstone beds, after dipping beneath the surface in the upper part of Clarke county, appear again at the Upper Salt Works, the White Limestone and other calcareous strata occupying a basin in the Buhrstone formation. Our own observations on the river in 1883, and later in 1885 in the western part of Clarke county and in Choctaw county, have shown that the Buhrstone rocks appear at least two intermediate points between the two limits observed by Professor Tuomey, viz., at Hatchetigbee and at Jackson.

Besides these outcrops of this formation along the rivers, we trace its outcrops all around the Hatchetigbee anticlinal as will be descibed in detail when we come to speak of this upfift, and we may therefore omit further paticulars here. The apparently anomalous occurrences of these strata in the lower part of Clarke county will be more particularly described below in connection with the "Displacements of the Buhrstone," as well as in the description of Clarke county, and to these the reader is referred.

East of the Alabama river, as may be seen by reference to the map, the northern limit of the Buhrstone from a point just below Johnson's wood yard, turns sharply northeastward to a point nearly east of Bell's Landing and six or seven miles distant therefrom. Then it turns southward six miles, sweeps around eastward and northeastward just south of the lower prong of Flat Creek, running up as far north as Cokerville, near the line between Monroe and Conecuh counties. Beyond Cokerville it again makes an abrupt turn southeastward and crosses the extreme southwestern corner of Butler county.

*First Bien Rep. Geol. of Ala., p. 150, 1850.

The two extreme northern points above noted, namely, that east of Bell's Landing and that at Cokerville, are upon dividing ridges, and this northward extension is no doubt in part due to this circumstance, but not altogether. The course of the two branches of Flat Creek has also much to do with this peculiar surface distribution of the strata. These two branches rise near Cokerville, in the northeastern part of Monroe county. The southern branch flows southward and westward, its channel being mostly in the Wood's Bluff strata, while the Hatchetigbee and Buhrstone form an escarpment on the southern border of the creek valley down to its confluence with the northern branch. The latter flows at first northward, then westward, and then southward to the point of confluence above noted. It thus flows out of the Wood's Bluff strata into the Bell's Landing, and even into the Nanafalia beds, coming back in its southward course into Wood's Bluff again, six or eight mile above the confluence.

Northward of the upper branch of Flat Creek we have a wide area of outcrop of the Nanafalia beds in the Grampian Hills of Wilcox county, in some places eight or ten miles in width.

Our observations have not given us the complete explanation of any of these irregularities, and this mere notice of them must suffice for the present.

Beyond Monroe county towards the east, the outcrop of the Buhrstone has been mapped by Mr. Langdon, and details of its exposures on Persimmon Creek and other localities in the southern edge of Butler, at several points on Conecuh River in the upper part of Covington, on Pea River, below Elba in Coffee county, and at several points in the central part of Dale and the upper part of Henry, will be found in his article in the present report. Beyond Butler county towards the east the Buhrstone does not impress itself upon the topography of the country as it does in the

western part of the state and in Mississippi, for it no longer appears in mountains or rugged hills. The characteristic aluminous rocks become also in this direction less and less abundant, and the whole Claiborne division has a certain unity in its features which would make a subdivision into Claiborne and Buhrstone somewhat difficult and arbitrary, if we had to do only with this formation in the eastern counties. Yet the prevalence of indurated clays and of sandstones in the eastern part of the state makes at least probable our identification of the Buhrstone there. In the county descriptions also are to be found details which are not here given.

§ 3.—The Lignitic.

All the strata lying between the Buhrstone and the Cretaceous, representing a thickness of 850 to 900 feet, have been classed by Dr. Hilgard under the two names of Lagrange (or Lignitic) and Flatwoods. Lately, Prof. Angelo Heilprin has proposed the name Eolignitic for both these divisions; but, since Dr. Hilgard had already used the name Lignitic in the same sense, that term has priority and must be retained.

The greater part of this subdivision is made up of laminated clays and laminated and cross-bedded sands of a prevailing gray color, except immediately below the Buhrstone, where for 200 feet or more they are of dark brown, often purplish colors. With the above mentioned laminated clays and sands are interstratified several beds of lignite and several beds holding marine fossils and usually characterized by the presence of glauconite or green sand.

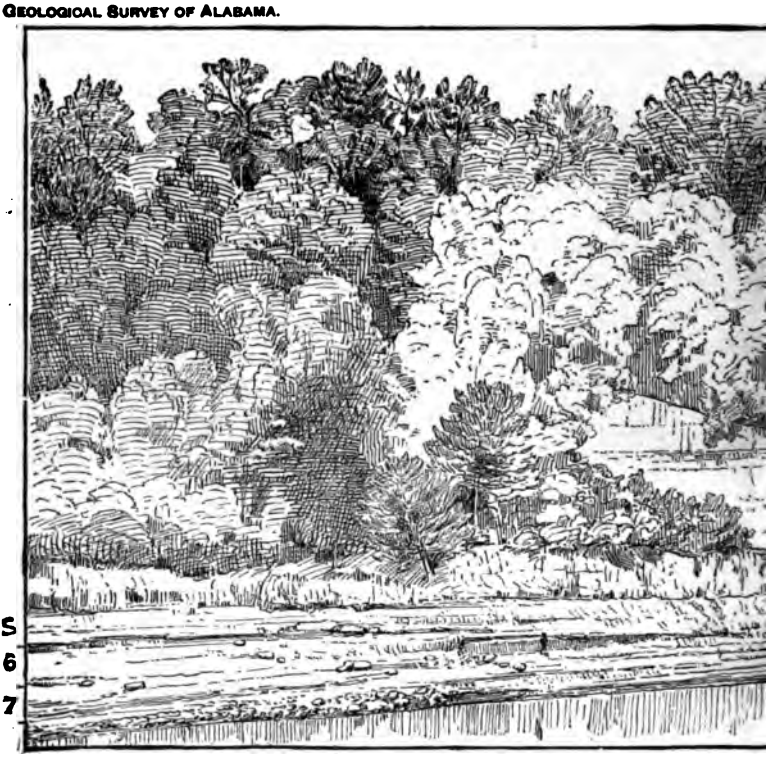
In Bulletin No. 43, we included all the Tertiary strata below the Buhrstone in the Lignitic division, but subsequent observations, especially east of the Alabama River, have led to the separation of the highly calcareous beds at the base of the Tertiary from the Lignitic, and to the placing of them

in a distinct division, to which we have given the name Clayton, which is a substitute for our former 7th section of the Lignitic, the Midway or Pine Barren section.

The lignite beds appear to be more numerous and thicker towards the west, and especially in Mississippi, while eastward of the Alabama River they become, as a rule, inconspicuous. Only one of these lignites, viz, that which appears at Coal Bluff, on the Alabama River, is of very considerable size, six or seven feet; they possess no very well marked characters by which they may be distinguished from one another; they are traced with difficulty across the country, since, being softer, they are more easily eroded than the associated rocks. On the other hand we have found the marine beds to retain their characteristic features to a remarkable degree; each has its peculiar association of fossils, most of them are also easily recognizable by lithologic and structural characters, and some of them may be followed with the greatest ease across at least three counties. These circumstances have led us to use the marine beds instead of the lignites for marking the different horizons of the Lignitic division, and provisionally we have thus used the six following marls, each marking a well defined horizon and each presenting its easily recognized paleontologic character:

a. The Hatchetigbee marls.
b. The Wood's Bluff or Bashi marl.
c. The Bell's Landing or Tuscahoma series.
d. The Nanafalia or *Gryphœa thirsœ* marl.
e. The Matthews' Landing and Naheola marls.
f. The Black Bluff or Sucarnochee.

Our account of the stratigraphy of the Lignitic division of the Alabama Tertiary will be more intelligible and more easily followed if we describe the strata in sections, each corresponding to and including one of the six marl beds above enumerated.



5. Lower part of purplish brown, sandy clays. 6.

(The human figure stands upon the bed which we call the middle marl.

HATCHETIGBEE—UPPER END

ray sands. 7. Bluish brown, sandy marl.

es are to the section on p. 40, and also to Fig. 2 of Plate XV.)

F, TOMBIGBEE RIVER.

(*a*) THE HATCHETIGBEE SERIES. (PLATE XXII.)

In this we would include all the strata intervening between the base of the Buhrstone and the uppermost of the Wood's Bluff fossiliferous beds, aggregating about 170 to 175 feet, as may be seen by consulting the engraved sections of Plate XXII, especially Fig. 1.

By far the greater part of the beds here included are sandy clays or clayey sands of brownish gray colors, alternating with bands of dark brown or purple color, the whole forming a tolerably well marked and in most cases easily recognized group. Where these brown clays have been much exposed to the action of the atmosphere, and consequently thoroughly leached, as occurs wherever they lie high up on the hills, they exhibit very much lighter and less characteristic colors. Their best exposures are to be seen at the localities more particularly described below, and at one of them, White Bluff and vicinity, the whole series occurs in actual superposition, only about sixty-five feet of it being somewhat obscured by slides. The distinctively marine deposits of this series consist of three or four shell or marl beds, separated by non-fossiliferous sands and clays (Plate VII).

(*a*) *Section at Hatchetigbee, Tombigbee River.* (*Plate XXII, Fig. 2.*)

1. Light colored, aluminous sandstones and indurated clays, forming a vertical escarpment back of the main bluff.....20 to 30 feet.
   These light colored claystones we consider to be the lowermost of the Buhrstone formation, and all the underlying to be Lignitic.
2. Sandy clays of brown, yellowish, and reddish colors interstratified. These are dark blue when moist, but of lighter colors when dry.....15 to 20 feet.
3. Heavy bedded, dark-brown clays, somewhat like No. 2, but of darker color when dry.....10 feet.
4. Yellowish, glauconitic marl.....2 to 3 feet.
   This bed shows a tendency to form at intervals hard concretionary ledges, which on weathering break off and roll down

the bluff and are piled in great numbers at its base. Some of these bowlders have a nucleus of shells, which, however, are not usually very well preserved.

5. Purplish brown, sandy clays, in the middle of which is a projecting ledge of dark colored clays which are harder but break up into small prismatic fragments upon drying and on exposure to weather.....15 feet.
6. Yellowish gray sands, striped with thin streaks of brown, sandy clay. These sands form, at intervals along the bluff, indurated, concretionary, rounded masses.....5 to 6 feet.
7. Bluish-brown, sandy, clay marl, containing many new forms of shells. The upper part more fossiliferous.....5 to 6 feet.
8. Laminated, grayish sands, interstratified with thin beds of brown or black, lignitic clay. These sands form rounded, concretionary masses, which project from face of bluff.....4 feet.
9. Heavy bedded, gray, sandy clays with streaks of brown clay. 8 feet.
10. Reddish, sandy marl, highly fossiliferous, forming concretionary bowlders. Remarkable for the great numbers of *Venericardia planicosta* Lam,, but containing also many other forms, such as *Athleta Tuomeyi* Con., and *Fusus pagodiformis* Heilprin, 4 to 5 ft.
11. Dark gray to brown sandy clays to water.....15 feet.

Beds No. 8 and 9 above form very conspicuous parts of the bluff, as they are striped with dark-brown, nearly black, bands of clay and resemble strongly a part of the section at McCarthy's Bluff described below.*

(*b*) At White Bluff, on the Tombigbee, as above stated, there is another exposure of the contact between the Buhrstone and the underlying Lignitic, which, however, includes in continuous exposure only the uppermost 25 feet of the latter formation. From the top of White Bluff down to the river level the distance is 275 feet by barometic measurements made at several different times. Of this, the uppermost 140 feet are shown in a clear perpendicular bluff and

*Between our joint visit in 1883 and my second in 1885 the appearance of the bluff was very materially changed by a landslide. In 1883 we saw about six feet below the marl bed No. 4 another of very similar character, which I have now reason to think was a mere repetition of No. 4, since I was unable to make out two such beds in 1885. I have, therefore, given only one in the section, though convinced of the existence of two at the time of our first visit.

consist of 115 feet of the light colored claystones of the Buhrstone formation and 25 feet of sandy clays of the Lignitic. The strata composing the rest of the slope of White Bluff are so much obscured by landslides that it is impossible to make them out satisfactorily, but the lowermost 70 feet of the beds which make this slope are well exposed on the banks of Witch creek and at Davis's Bluff, near by. Between these two parts of the section there are some 65 feet of strata not seen here, which include the Hatchetigbee marls, &c. In proof of this, I found on the slope, a few feet below bed No. 3 of the accompanying section, a fragment of hardened, glauconitic marl with a few badly preserved fossils. The marl resembled that described in No. 4 of the Hatchetigbee section above. The fossils were, however, too obscure to be identified.

All this is shown in the following section and in Plate XXII, Fig. 1.

Section of White Bluff and Davis's Bluff, Tombigbee River.

1. Aluminous sandstones and claystones, of light color, forming a vertical bluff, the details of which it is impossible to examine closely, Buhrstone rocks.....115 feet.
2. Grayish, sandy clays, with a layer about 18 inches in thickness at its base, containing fragments of lignitized stems and twigs. 20 feet.
3. Sandy clays, with a layer at bottom about 8 inches thick, consisting of alternate layers (one-fourth of an inch in thickness) of lignite and sand..... 5 feet.
4. Strata not seen, covered by landslides*.....65 feet.
5. Gray, sandy clays, striped by brownish purple bands of clay, containing few if any fossils, except that about 12 feet above the water there occurs a thin bed with a few fossil shells and some 12 feet above this a single specimen of *Athleta Tuomeyi* was found sticking in the clay†.....70 feet.

*A fragment of glauconite sandstone with fossils was picked up from the surface in this part of the section a few feet below the base of No. 3.

†These beds, as well as those included in No. 4, are covered by the debris of landslides at White bluff, but they are well shown in the banks of Witch Creek, which washes the base of White Bluff, and at Davis's Bluff, half a mile above, where we get the lower 70 feet of the section (No. 5.)

White Bluff is in the southwestern part of Sec. 14, T. 11 N., R. 1 W., just below the mouth of Witch Creek.

(c) Above this, the river bends towards the west, and in the northwestern part of Sec. 6, T. 11 N., R. 1 W., at McCarthy's Ferry, the strata which make the lower part of the preceding section are again exposed, as may be seen from the following section:

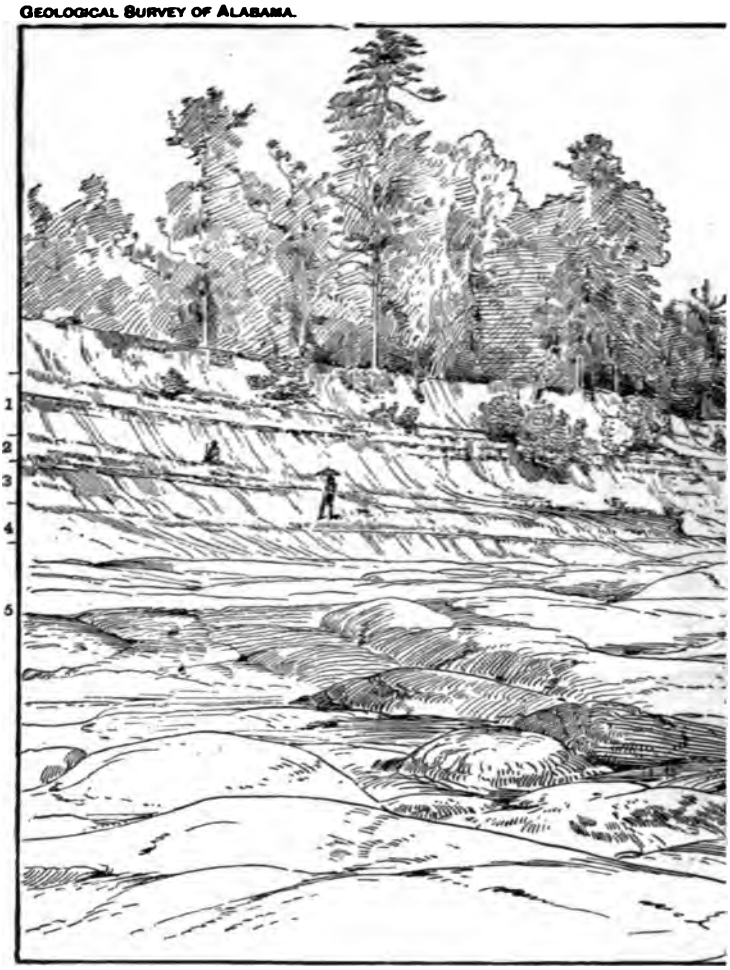
Section at McCarthy' Ferry, Tombigbee River. (Plate XXII, Fig. 3.

1. Sandy clays interlaminated with clays less sandy, all of light gray colors, but along the whole length of the bluff there are parallel bands of much darker clays, which make a very conspicuous marking.....50 to 55 feet.
2. Laminated clays and sands, firm and compact at base, forming a projecting ledge which divides the bluff into two parts, 4 to 5 feet.
3. Pyritous, sandy clays, with two or three bands of darker color; the sands are indurated in places, forming bowlder-like masses.....20 to 25 feet.

The dark bands which mark the bluff and which look at a distance like lignite beds are found upon closer inspection to consist of thin layers of dark bluish gray clays interbedded with thin streaks of gray sand. The whole 75 feet of this section appear to be barren of fossils.

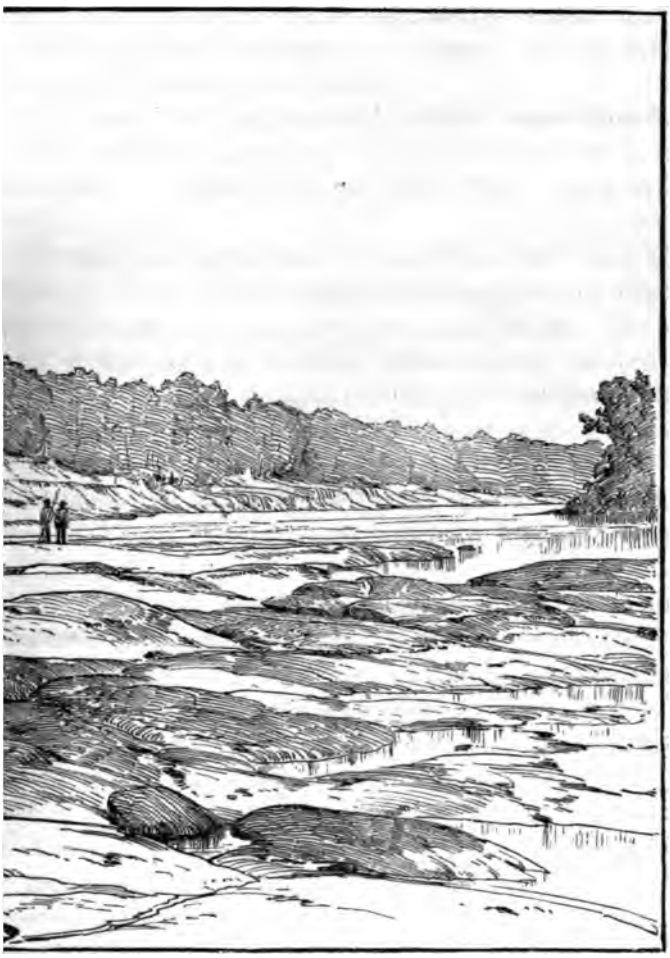
At the base of the bluff lie great numbers of fragments of the silicious and aluminous rocks which charaterize the Buhrstone formation and which have rolled down from the hills that rise a short distance back of the immediate bluff of the river. These hills are composed entirely of the Buhrstone for a vertical distance ot 270 feet. (See Plate XXI, Fig. 3.) This is the greatest thickness of Buhrstone rocks that has been measured in one section, except at one other place in the same range of hills.

Above McCarthy's Bluff I failed to find any outcrop in place of the Hatchetigbee marls, though a fragment of indurated marl with fossils was seen there, about 50 feet below the base of the Buhrstone. A short distance northward, on



1. Dark gray clays. 2. Bluish, sandy clay, fossiliferous. 3. Bluish, sandy cla

(The figures refer to section on p. 44, and



ıs. 4. Greenish, sandy clay, highly fossiliferous. 5. Greensand marl.

n given in Fig. 7 of Plate XVI.)

TOMBIGBEE RIVER.

the road to Mount Sterling, some 10 to 11 miles south of Butler, the road descends over 250 feet of Buhrstone rocks, below which I saw in 1885 an indurated greensand marl with fossils embedded in brown sandy clays. This is doubtless one of the Hatchetigbee marls.

The position of the McCarthy's Bluff beds with reference to the Buhrstone and to the Davis's Bluff beds is shown on the general section in Plate XXI, Fig. 3, and in Plate XXII, Fig. 3.

Up the Tombigbee River from White Bluff and Davis's Bluff to Wood's Bluff, similar dark gray, sandy clays with darker bands are displayed in the river banks. The thickness of the strata between the Buhrstone and the top of the Wood's Bluff marl is about 175 feet, of which the lower 100 feet are well characterized by a prevailing dark brown or slightly purple color and by the absence of fossils, except an occasional band of lignitic clay or a sandier band with a few marine shells. The upper 75 feet are more fossiliferous and varied in appearance.

In these lower, dark, sandy clays there appear concretionary masses of silicious matter, sometimes almost a flint, of approximately spherical shape, and made up of concentric layers or shells. These concentric shells are usually separated by a thin layer of pure quartz of fibrous texture, the fibres being perpendicular to the surfaces of the spheres. These concretions are very commonly looked upon as petrified turtles by the people of the vicinity. They vary from 6 inches to 4 or 5 feet in diameter. In other places the clayey sands themselves are cemented together into rounded concretions, with a nucleus of black lignitic matter.

Where the dark brown or purple, clayey sands above described occur at considerable elevations above the water and have been thoroughly leached and desiccated, they exhibit very much lighter colors. They are seen under such condition on the hills back of Yellow Bluff, on the Alabama river,

and in the country between the two rivers. It is only along the river bluffs and low places, where they are kept more or less moist, that the dark purple and brown shades are so characteristically displayed.

In the vicinity of the Tombigbee river the Hatchetigbee beds are again exposed along the crest of the Hatchetigbee anticlinal already referred to, which has been followed from near Salitpa in Clarke county, by Hatchetigbee bluff, through Bladen Springs out nearly to Silas P. O. in Choctaw county. The details of these outcrops will be found under the special description of this uplift. Again we find the dark colored clays of this series just below Jackson in Clarke county, in the vicinity of the sulphur spring which probably takes its rise from these clays.

The Hatchetigbee clays cross the Alabama river just below Johnson's Island, and by reason of the Lower Peach Tree anticlinal they are again found above the river bluff at Yellow Bluff. Their outcrop eastward through Monroe follows a very irregular line. Since these beds and the Wood's Bluff marls are always so closely associated it will save repetition to speak of their extension eastward in connection under the head of the Wood's Bluff. Under the county descriptions of Choctaw, Clarke and Monroe, and in the paper of Mr. Langdon, will be found additional particulars of the distribution of the outcrop of the Hatchetigbee beds which it would be undesirable to repeat here.

B. The Wood's Bluff or Bashi Series. (Plates XXII, XXIII.)

The first beds of marine fossils of any consequence below the series of brown and purple clays above mentioned occur at Wood's Bluff, on the Tombigbee, and just below Johnson's Island, on the Alabama River; also on Bashi Creek and its tributaries in Clarke county, and at numerous other localities to be given below. We have given these beds the name of the *Wood's Bluff* or *Bashi Marl.* They are

from 15 to 20 feet in thickness, and are highly fossiliferous, hold a very considerable percentage of greensand, and the marl has a tendency to become indurated by carbonate of lime into rounded, bowlder-like masses of glauconitic, fossiliferous limestone. These bowlders may be formed in any part of the beds, but are more commonly seen in the upper half, and when this is the case the loose greensand marl below is easily washed out, giving rise to the formation of caves, sometimes of considerable dimensions. Immediately below this marl, and usually within 25 feet of it, are at least four or five thin seams of lignite, varying from a few inches up to eighteen, in thickness.

All these characters render the Wood's Bluff marl easily recognized, and it has been traced by me from the western part of Choctaw across to the eastern part of Monroe county without any essential change in its quality. It has become one of our most important geologic landmarks.

Some 35 to 40 feet below the lowermost of the thin, lignitic beds immediately underlying the Wood's Bluff marl, and separated from it by yellowish, cross bedded sands, is another lignite, about two feet in thickness, at the base of which we wish to draw the line between the Wood's Bluff and the Bell's Landing series. As thus defined, the Wood's Bluff series includes the strata intervening between the purplish brown, sandy clays, above described, immediately overlying the Wood's Bluff marl, and the two feet of lignite. The thickness represented is about 80 feet. The most complete section of the whole series is at Yellow Bluff, on the Alabama river. (See Plate XXIII, Fig. 1.)

The best exposures of the marl bed are to be seen at Wood's Bluff, on the Tombigbee River, and on the tributaries of Bashi Creek in Clarke county, in the immediate vicinity of Wood's Bluff, although, as stated above, the marl may be readily traced across Choctaw, Clarke, and Monroe counties, exhibiting at many places away from the

rivers very fair sections. On the immediate banks of the Alabama River the marl does not make much show, though it may be seen below Johnson's wood yard.

Sections.—We give here only three sections, showing the details of the marl bed and of the strata underlying down to the top of the next, or Bell's Landing, series.

(*a*) *Section at Wood's Bluff, Tombigbee River.* (*Plate XXII, Fig. 1, and Plate XXIII, Fig. 7.*)

Orange sand (Lafayette) .....20 feet or more.

1. Dark brown or bluish black, laminated clays, breaking up into small fragments, 6 to 8 feet, at the upper end of the bluff, but rising 10 or more feet farther down. These clays are identical with those at the base of the White Bluff section. 8 to 10 feet or more.
2. Dark bluish, sandy clay, turning red on exposed and weathered surfaces and capped with a hard ledge which may be easily traced down the river nearly to Davis's Bluff* .....3 feet.
3. Bluish, laminated clay or sandy clay, very much like No. 2 in color and texture, but containing no fossils, or very few, and not appearing red at the surface, of variable thickness. 5 to 3 feet.
4. Bluish or greenish, sandy clay, somewhat indurated, of decidedly reddish color on the surface, highly fossiliferous, characterized by *Turritella lineata* Lea and *Dentalium microstriatum* Heilpr., but containing also *Ancillaria staminea* Con., a small Natica *Pyrula multangulata* Heilpr., *Corbula oniscus*, *Infundibulum trochiformis* Lea, a *Phorus*, and a small oyster. The lower part of this bed passes gradually into the greensand marl No. 5 and is the best collecting ground, as the material is less indurated and the shells are more easily removed.....3 to 4 feet.
5. Greensand marl to the water's edge.....10 to 12 feet.

The upper part of this marl is quite soft and friable, but just above the water's edge it becomes indurated and shows a disposition to form rounded, bowlder-like masses, quite hard and firm and resembling a limestone. That this indu-

*This bed is highly fossiliferous, containing *Lævibuccinum striatum* Heilpr. (which appears to be confined to this particular horizon), *Athleta Tuomeyi* Con., *Fusus pagodiformis* Heilpr., *Venericardia planicosta* Lam., *Actæon pomilius*, Con., a small Natica, *Pleurotoma acuminata* Sow., harks' teeth, *Ancillaria staminea* Con., a small Cytherea, &c.

rated part is of the same nature as the softer greensand above and below it, is seen from the circumstance that the indurated bowlders are sometimes near the top, sometimes near the bottom of the greensand stratum. The accompanying view (Plate VIII) shows well the large bowlder-like masses of the indurated greensand, No. 5. Passing through the central part of this marl bed is a layer of *Ostrea compressirostra* Say, with thick and ponderous shells.

(*b*) About two miles from Wood's Bluff, on the banks of Bashi Creek, there is the following exposure (Plate XXIII, Fig. 7):

Section near Wood's Bluff.

1. Yellowish gray limestone or indurated marl, like that seen at the base of the Wood's Bluff section ..... 10 feet.
2. Greenish blue, fossiliferous sands* .....8 feet.
3. Seam of lignitic clay, laminated and jointed.....6 inches.
4. Brown, laminated, joint clay, passing below into a greenish, non-fossilerous sand.....4 feet.
5. Laminated, greenish-gray clay, alternating with thin seams of dark purplish, lignitic clays, giving the exposure a beautiful and regularly striped appearance†.....5 feet.
6. Thin layer of lignite.....about 12 inches.
7. Gray clay to the water's edge.

(*c*) The strata which intervene between the Wood's Bluff and the Bell's Landing series of marls, together with 130 feet of the beds overlying the former, are to be seen in a continuous section of 250 feet at Yellow Bluff and in the hill which lies just back of the bluff (Plate IX). Here all the strata between the two marl beds mentioned are exposed in actual and unmistakable contact at the river bluff, where

*These sands are frequently washed out from beneath the limestone or indurated marl, forming caves which are to be seen wherever the Wood's Bluff marl occurs.

†The dark clays in this stratum appear to resist denudation better than the greenish clay, so that they project slightly from the face of the bluff.

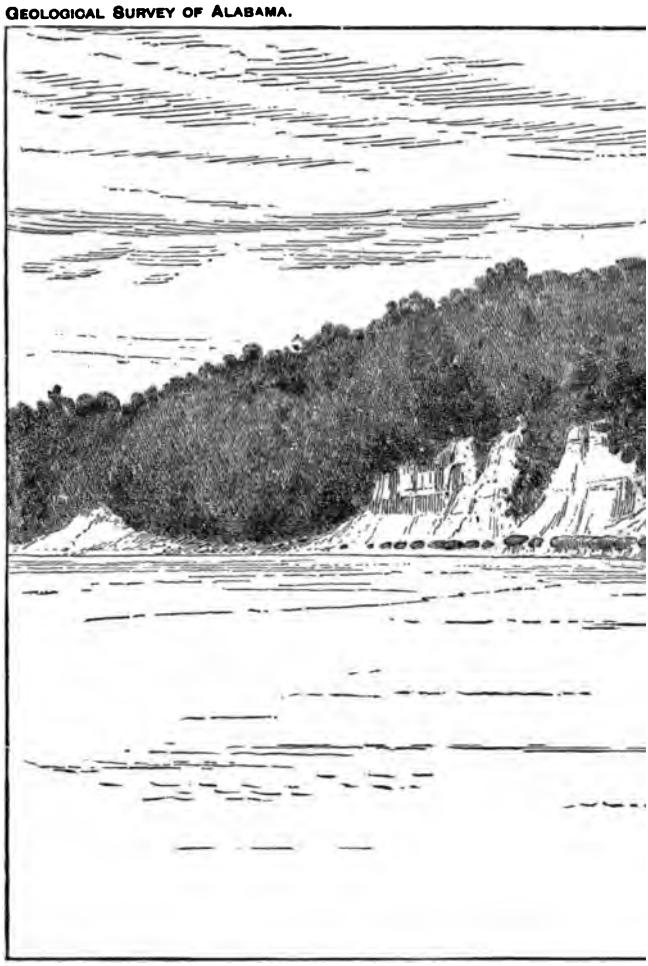
there is an uninterrupted section of 120 feet. This is one of the most important sections we have, and it was obtained in the summer of 1885.

Section at Yellow Bluff, Alabama River. (Plate XXIII, Fig. 1.)

1. Laminated, gray, sandy clays of light color, variously interstratified with sands; in places there is a white or very light colored clay, and in other places cross-bedded sands, interlaminated with thin sheets of white clay; reddish sand abundant near the top of the section, which is one mile back from the river. Thickness by barometer.....130 feet.

   These beds are the same as those shown on the Tombigbee River below Wood's Bluff, at Davis' Bluff, and at White Bluff, and belong to the Hatchetigbee series; but, lying high up on the hills and exposed to sun and weather, they are uniformly much lighter in color than on the Tombigbee River, where they are near the water level. Below this we have a gentle slope, along which about fifty feet of beds are exposed (Nos. 2 to 4), and below that the perpendicular bluff of the river, some seventy feet (Nos. 5 to 10).
2. Greensand marl, with Wood's Bluff fossils (*summit of the Wood's Bluff series*), with indurated, rounded masses above, and loose marl below.....about 6 feet.
3. Blue clay.....1 foot.
4. Gray, sandy clays with a slight tinge of purple, holding four or five thin seams of lignite, each one foot or less in thickness. The actual positions of these lignite beds are slightly obscured by landslides.....40 to 50 feet.
5. Reddish, cross-bedded sands.....20 feet.
6. Lignitic clay and lignite (*base of Wood's Bluff series*).....2 feet.
7. Reddish sands slightly laminated.....15 feet.
8. Laminated, sandy clays in perpendicular cliff.....20 to 25 feet.
9. Greensand marl in two parts separated by one foot of sandy clay without fossils. The upper part, one foot thick, holds chiefly *Ostrea compressirostra* and *Venericardia planicosta*, while the lower part, six feet thick, contains all the characteristic fossils of the Bell's Landing series, *Voluta Newcombiana*, large *Turritella Mortoni*, *Rostellaria trinodifera*, &c. This upper part shows strong tendency to harden into round, bowlder-like masses; in all.....about 8 feet.

   This bed, No. 9, is very clearly marked in the accompanying view (Plate IX) by the line of bowlders near the water's edge. The lignite, No. 6, occurs near the top of the cliff, but does not show out in the picture.



YELLOW BLUF

ABAMA RIVER.

10. Greenish, ferruginous sands interlaminated with thin sheets of clay, passing into a dark blue, sandy clay at the water level.....7 feet.

In this section the beds numbered 5 to 10, inclusive, are seen in the actual bluff of the river about half a mile or less below the steamboat landing. The beds numbered 2 to 4, inclusive, together with about forty feet of the lower strata of No. 1, are seen on the top of the bluff, along the road leading up the hill, and they directly overlie the beds exposed in the river bluff. Nos. 2 to 6, inclusive, represent the Wood's Bluff series.

On the Tombigbee River the strata between the Wood's Bluff marl and the Bell's Landing marl at Tuscahoma are not well exposed, and it would have been impossible to get any clear understanding of the stratigraphy from the bluffs of that river alone. It is fortunate that the section, here so faulty, is so complete and satisfactory on the Alabama River.

The few localities where Tertiary strata make the banks of the river, from Wood's Bluff up to Tuscahoma, are given below.

Across a narrow neck of land from Wood's Bluff at Cade's Bend, the Wood's Bluff marl is again seen in the river bluff.

At the mouth of Bashi Creek, as above shown (see Plate XXIII, Fig. 7), the lower strata of the marl, as well as two of the underlying lignites, are exposed.

Two others of these lignites are seen a little higher up the river, at Pickens' Landing, where we have the following section:

(*d*) *Section at Pickens' Landing, Tombigbee River.*

1. Gray, laminated, sandy clays .....10 feet.
2. Lignite.....12 to 18 inches.
3. Bluish, clayey sands with yellowish division planes....6 to 8 feet.
4. Lignite.....2 feet.
5. Gray, sandy clays to water level.....1 to 2 feet.

The beds are undulating and in some places show a dip towards the northwest, but the general dip of the surrounding strata is southwest.

Above Pickens' Landing gray, sandy clays are shown in the river banks at Magnolia Landing and one or two other points; but these clays contain no fossils, so far as our observations went. The Pickens' Landing lignites are found in the hills about the headwaters of Horse Creek and elsewhere in the lower part of Marengo county.

From the sections represented on Plates XXII and XXIII it will be seen that the Wood's Bluff marl lies embedded in a great thickness of clays and clayey sands, a circumstance which has an important bearing upon its economic value. The disintegration of the clays produces heavy clay soils, which are thoroughly marled by the Wood's Bluff beds, and they form in consequence some of the most productive and lasting soils of the Tertiary group. We have as instances the heavy, calcareous, clay soils which occupy a broad belt north of Butler, in Choctaw county; the productive soils of parts of the Tallahatta and Bashi creeks region; the clay hill soils of the eastern part of Clarke and the western part of Wilcox counties, between Choctaw Corner and Lower Peach Tree; the celebrated Flat Creek lands of Monroe county, &c. Some descriptions of these soils, with analyses, were presented in the Report of the Geological Survey of Alabama for 1881–82.

The descriptions above given show sufficiently well the general characteristics of the Wood's Bluff marl and its position in the geological column. Many additional details concerning this interesting formation will be found under the county descriptions of Choctaw, Clarke, and in Monroe and in connection with the Lower Peach Tree anticlinal. On account of the close association of this and the Hatchetigbee series they may best be spoken of in connection in describing their outcrops east of the Alabama river.

These beds cross the Alabama river just below Johnson's Island and on the Monroe side of the river, then turn northeast up the river to pass around a point of Buhrstone lying nearly east of Bell's Landing, then they make a great bow southward and appear along the borders of the lower prong of Flat creek, whose lowlands are thoroughly marled by them.

Beyond Turnbull they again bend northward around another point of the Buhrstone about Activity P. O. from which they turn southeastward following the course of Sepulgah river into Butler.

From Butler county eastward to the Georgia line the details are to be found in the paper of Mr. Langdon, who finds that while the Hatchetigbee may be easily traced across Butler from its western border through the Oakey Streak country, beyond that the traces of it are obscure and not recognizable till Pea River is reached. He fails to identify the Wood's Bluff strata with certainty, through Butler, Crenshaw and Covington, but finds good sections on Pea River below Elba, and also fairly good ones on Choctawhatchee and along the Chattahoochee, the Hatchetigbee being generally shown in the same localities. Both these formations lose their distinctive characters coming eastward, and at the same time thin down very considerably. Mr. Langdon assigns only ten feet to the Hatchetigbee and forty-four to the Wood's Bluff on the Chattahoochee river.

Useful materials.—The principal thing of economic value included in the Wood's Bluff strata is the marl bed, which, however, is not likely to be utilized by the present generation at least of our people. This marl has no great proportion of phosphoric acid and its value rests therefore upon its percentage of lime chiefly. The question of its efficacy as a fertilizer is answered in a most satisfactory manner by nature itself wherever the washings from the marl bed are incorporated in soil.

This may be seen about most of the outcrops of marl in what the people call the Lime hills. The growth of beech, poplar, sweet gum, white oak, and the draping of long moss upon all, attest the character of the soil thus produced.

Below the marl bed there are several beds of lignite close together. One of these shows two feet thickness at Pickens' Landing, and from fragments of it seen along the course of Horse creek a short distance away from the river, this thickness is even exceeded in places.

The following analysis by Dr. Phillips will show the nature of this bed:

Lignite from Pickens' Landing.

Volatile combustible matters	42.20
Fixed carbon	86.60
Ash	8.80
Moisture	12.40
Total	100.00

C. THE TUSCAHOMA OR BELL'S LANDING SERIES.

(PLATE XXII, FIGS. 1 TO 6.)

This series includes two important fossiliferous beds, separated by about twenty-five feet of gray, sandy clays. Between the lignite, which forms the base of the preceding division, and the upper marl of this series, there are some forty feet of reddish sands and laminated, gray, sandy clays, and below the lower marl about sixty feet of sandy clays of the prevailing gray color, rather massive in the lower part. About fifty feet below the lower of the two marl beds, and ten feet above the base of this series, there is a third small greensand bed one foot or less in thickness containing fossils. The entire series comprises about one hundred and forty feet of strata, which, as a whole, are gray, sandy clays, becoming more and more massive toward the base, while they are more thinly laminated and more mixed with sands near the summit of the section. The strata which lie be-

tween the Wood's Bluff marl and the uppermost of this series are about sixty feet of sandy clays, containing several thin seams of lignite, all of which are exhibited in direct superposition at Yellow Bluff, and have been placed, as above shown, with the Wood's Bluff series. The upper marl bed, which is the Bell's Landing marl bed proper, is some ten feet thick, contains greensand, and indurates into bowlders, fine examples of which are to be seen at the base of the bluff at Bell's Landing. The marl is characterized above all others in the Tertiary of Alabama by containing gigantic specimens of shells which at other localities are of moderate size. The lower bed, known as the Gregg's Landing marl from its occurrence at the landing of that name, is four or five feet in thickness and is of clayey material. It has a peculiar group of fossils.

The fossil bearing beds of this series are best exposed along the banks of the Alabama river at Bell's Landing, Gregg's Landing, Peeble's Landing, Lower Peach Tree, and Yellow Bluff; and on the Tombigbee at Tuscahoma, Turner's Ferry, near the mouth of Shuquabowa creek, and at Barney's Upper Landing. The exposures on the Alabama are much more satisfactory.

Unlike the Wood's Bluff marl, the marls of this series make comparatively little show inland from the rivers and exercise little, if any, influence upon either the soils or the topography of the country in which they come to the surface. I am not certain that either the Bell's Landing marl or the Gregg's Landing marl has been identified at any distance from the rivers, while the Wood's Bluff marl can be followed with ease from the Mississippi line as far eastward as we have been.

Sections —The following sections illustrate the occurrences of the Bell's Landing beds along the two rivers:

(a) Section at Bell's Landing, Alabama River. (Plate XXIII, Fig. 2.)

1. Yellowish red, cross bedded sands.....15 feet.
2. Lignite.....about 2 feet.
3. Laminated, sandy clays, with a few large, bowlder-like concretions.....10 feet.
4. Yellow, stratified sands alternatingwith gray, sandy clays. 15 feet.
5. Gray, sandy clays.....15 feet.
6. Greensand marl forming large concretionary bowlders and holding gigantic specimens of *Rostellaria trinodifera*, *Turbinella pyruloides* Con., *Fusus pagodiformis* Heilpr., *Voluta Newcombiana* Whitfield, &c. The bowlders cover all the lower part of the slope below the landing. The marl beds... about 5 to 10 feet.
7. Dark gray, laminated, sandy clays, black when wet, but light gray when dry.....25 feet.
8. Bluish green, sandy clay marl.....1 to 2 feet.
9. Dark gray, sandy clay to water level.....4 feet.

Above Bell's Landing the strata of this series are exposed along the river as far as Yellow Bluff, and the most important localities are given below.

(b) Section at Gregg's Landing, Alabama River. (Plate XXIII, Fig. 4.)

1. Greensand marl with concretionary bowlders, the same as No. 6 at Bell's Landing.....5 feet.
2. Gray, sandy clays.....20 to 25 feet.
3. Dark gray or bluish, sandy clay or clayey sand containing well preserved fossils, many of which are peculiar, and some identical with those at Wood's Bluff, such as *Pyrula multangulata* Heilpr. and *Fusus subcalarinus* Heilpr. This bed has an indurated ledge of variable thickness at the base and is in all about.....4 to 5 feet.
4. Laminated, sandy clays to the water level.....about 10 feet.

This bluff extends at least one mile down the river from the landing, and along this whole distance there have been landslides, and the two marl beds have in consequence been thoroughly mixed up. In some places the upper marl has slid down and completely covered the lower; in other places lower marl is in its proper position, but the upper has slipped down *below* it; sometimes the two are in direct contact, the upper above; but in all cases a careful inspection of the

original bluff a short distance back from the river slope will reveal the true relative position of the two beds. I am particular in calling attention to these circumstances because at many points these broken off parts of the bluff appear to be in place, and where the two beds, apparently in place, are thus brought into contact or their relative positions are reversed, the commingling of the two sets of fossils would lead the incautious observer far astray.

The next exposure is about a mile below Lower Peach Tree, at Peebles' Landing.

(c) *Section at Peebles' Landing, Alabama River.* (*Plate XXIII, Fig. 3.*)

1. Yellow sands .....1 foot.
2. Lignite and lignitic clay.....about 2 feet.
3. Reddish, laminated sands.....10 feet.
4. Dark gray clays and sands interstratified.....30 feet.
5. Greensand marl, No. 6 of Bell's Landing section.....8 feet.
6. Dark gray clays and sands variously interstratified.....25 feet.
7. Dark bluish gray, clay marl, Greggs' Landing.....12 feet.
8. Dark gray sandy clays extending to the foot of hill, 20 feet above the river level..... .....about 14 feet.

The next locality is Lower Peach Tree, where we have a repetion of the above section, together with beds extending some 45 to 50 feet lower.

(d) *Section at Lower Peach Tree, Alabama River.* (*Plate XXIII, Fig. 5.*)

1. Sandy, laminated clays at the top of the bluff.....about 10 feet.
2. Greensand marl containing the characteristic fossils of the upper bed at Bell's Landing.....8 to 10 feet.
3. Sandy, laminated clays, of gray color, but with some reddish layers.....20 to 25 feet.
4. Bluish, sandy, clay marl containing a number of peculiar fossils. To this bed we have given the name of *Greggs' Landing Marl*, as it is seen at Greggs' Landing better than elsewhere.....5 feet.
5. Sandy clays of prevailing gray color, varying in degree of sandiness and coarseness of lamination, without fossils so far as we could discover.....50 feet.
6. Coarse grained greensand marl, indurating into bowlders in places, containing some fossils, which are also in the bed No. 4, above.....1 foot.
7. Gray, sandy clays to water level.....10 feet.

The last exposure of the beds of this series up the Alabama River is seen at Yellow Bluff, the section of which has already been given (Plate XXIII, Fig. 1).

The exposures at Lower Peach Tree and at Yellow Bluff, in part overlapping, give us a continuous section of some 250 feet, and the two, taken with the exposures at Wood's Bluff, Davis' Bluff, White Bluff, and Hatchetigbee, all of which overlap in some parts, afford a series which is without a break from the base of the Buhrstone down 390 to 400 feet. It would be impossible to find anything more satisfactory for making out the stratigraphy of this part of the Tertiary group.

On comparison of all these sections it will be seen that the Bell's Landing marl, at Bell's Landing, is about 30 feet above the river level; at Gregg's Landing, about 40 feet; at Peebles' Landing, about 60 feet; at Lower Peach Tree, 85 feet or more; while at Yellow Bluff it is only about 7 feet above the river level. The beds rise with tolerably uniform inclinations (40 feet to the mile) up to Lower Peach Tree, and then sink rapidly, Lower Peach Tree being about on the summit of the anticlinal or roll. As a consequence of this undulation the beds involved are spread in a north and south direction over a much greater extent of surface than is usually the case where the average dip is uniformly southward some 30 or 40 feet to the mile. This roll in the strata may be traced from Choctaw county to Monroe county, but seems to be most pronounced in the lower part of Marengo county and the upper part of Clarke county. In the southern part of Wilcox county and the northern part of Monroe county the undulation involves in general a lower series of rocks, to be mentioned presently.

We have seen above that the exposures along the Tombigbee River of the strata between the outcrop of the Wood's Bluff marl and the Tuscahoma beds at the landing of that

name are discontinuous and unsatisfactory—especially above the outcrop of the Pickens' Landing Lignites.

At Tuscahoma we have the first considerable bluff above Wood's Bluff. In the section below given we include not only the strata actually appearing in the bluff at the landing, but also those which make the bank for half a mile or more down the river. This section, as will be seen, is about the equivalent of that at Yellow Bluff on the Alabama.

(*e*) *Section of Tuscahoma, Tombigbee River.* (*Plate XXIII, Fig. 6.*)

1. Indurated sands, with a line of bowlders at the base. This stratum is eight to ten feet thick at the warehouse, but down the river it thickens to twenty feet or more, and a second line of ferruginous, indurated bowlders appears about ten feet above the first. The strata above the upper string of bowlders are more distinctly luminated and interbedded with thin sheets of clay. This is most clearly shown about six to eight feet above the upper line of bowlders. Taken altogether there are about 30 ft.
2. Light bluish gray, sandy clays, which are somewhat striped with harder projecting seams.....35 to 40 feet.
3. Sandy marl, containing the Bell's Landing fossils, but in badly preserved condition.....2 feet.
4. Dark blue, massive clay.....3 to 4 feet.
5. Thin streak of greensand, with *Venericardia planicosta* and other Bell's Landing fossils to water level.....6 inches or more.

About half a mile below the landing there is a low bluff capped by the upper string of bowlders above mentioned, which form a little terrace forty or fifty feet wide, the farther limit of which is made by another low bluff of second bottom deposits.

The lignite which occurs about thirty-five to forty feet above the marl bed at Yellow Bluff and at Bell's Landing was not observed at Tuscahoma, those parts of the bluff where it would be looked for being badly weathered.

The massive clay, No. 4, which separates the two parts of the marl bed, is everywhere perforated by *pholas*, and in most of the perforations their shells are still to be found. Mr. T. H. Aldrich, who made this observation, also saw these

shells in the clay which occurs below the lower marl bed at Bell's Landing.

The Tuscahoma (Bell's Landing) marl, with its accompanying beds, may be followed up the river without essential interruption to Barney's Upper Landing, as shown in the following sections (Plate XXIII, Fig. 6.):

(f) Section at Turner's Ferry, Tombigbee River.

1. Indurated sands, No. 2 of the Tuscahoma section.....5 feet.
2. Marl with badly preserved shells.....3 to 4 feet.
3. Bluish clay, becoming sandy below.....3 to 4 feet or more.

From Turner's Ferry these beds rise, going up stream, and at the mouth of Shuquabowa Creek they give the following section:

(g) Section at mouth of Shuquabowa Creek, Tombigbee River.

1. Greensand marls.....3 to 4 feet.
2. Dark bluish black, massive clay.....2 feet.
3. Hard sands, passing into sandy clay below.....5 feet.
4. Light colored, nearly white, cross-bedded sands, about 3 feet, with 3 to 4 feet below it of sands with clay partings, in all 6 to 8 ft.

Above this place the strata sink towards the north, and at Barney's Upper Landing only three feet of the beds immediately below the marl are above the water, as seen below.

(h) Section at Barney's Upper Landing, Tombigbee River.

1. Laminated, sandy clays, striped with somewhat harder and more clayey seams, in all.....15 to 20 feet.
2. Sandy, fossiliferous bed, with greensand in the lower parts, more clayey above. The fossils in this bed are badly preserved, as was the case also at Tuscahoma, Turner's Ferry, &c., but are the characteristic Bell's Landing forms..... 5 feet.
3. Dark bluish to gray clays to water level.....3 feet.

From Barney's Upper Landing to the mouth of Horse creek no Tertiary strata appear on the river banks, but just above that point the river bank is formed by dark gray, clayey sands or sandy clays, which continue up to Williams'

Gin, where they overlie the first of the beds containing *Gryphœa thirsœ* Gabb, and in consequence may be better classed with the next section.

Eastward of the Alabama river the strata of this formation are somewhat difficult to follow, since they show nothing very distinctive, and appear to be very nearly barren of fossils. The residual sands from their disintegration, while somewhat closely resembling the surface loam of the Lafayette, are yet generally to be distinguished therefrom upon close observation. This residuum forms a yellowish clayey loam soil with short leaf pine and the varieties of upland oaks as characteristic timber, and the general appearance of the country is usually sufficiently distinctive. Typical Bell's Landing scenery may be seen about Newtown Academy and thence eastward as far as Bursonville in Wilcox county, and also in the same direction in Butler.

According to Mr. Langdon these beds continue across the country to the Georgia line with undiminished thickness, though their identification has been made partly on lithologic characters and on their position with reference to other identifiable beds. On Pea river near Elba, and on Choctawhatchee in the upper part of Henry county, Mr. Langdon finds these strata fairly well exposed, and below Fort Gaines they form the banks of the Chattahoochee river for many miles. One persistent characteristic entirely across the State is the tendency to the formation within the Bell's Landing sands of rounded concretions of indurated sand, or bowlders as we have called them.

From the foregoing it may be inferred that the Bell's Landing beds afford no useful materials beyond the marls along the two western river banks, and even there the marls are generally too much mixed with sand to be of anything more than strictly local value. The characteristic soil has already been mentioned, and this seems to be persistent and

somewhat uniform where not covered by more recent surface formations such as the Lafayette. Some interesting details of distribution are given under the county descriptions of Choctaw, Marengo, Clarke and Wilcox.

D. The Nanafalia Series, Including the Coal Bluff Lignite.

Divisions.—The series of strata to which the Nanafalia marl has given the name, broadly considered, is susceptible of threefold division upon the basis of lithological and paleontological characters, viz:

First. Forty feet or more of indurated, gray clays and sandy clays, in part glauconite and rather closely resembling some of the materials of the Buhrstone. Near the base of this first division there are hard, sandy clays filled with shell casts, chief among which are Turritellas and Cythereas.

Second. Seventy-five to eighty feet of yellow and reddish and whitish sands, alternating with greensand beds, highly fossiliferous. The characteristic shell in both the sands and the greensands is *Gryphœa thirsœ* Gabb. In the upper fifty or sixty feet of this division this shell is found either in thin greensand beds or sparingly distributed through the other sands. In the lower twenty feet there are thick greensand beds literally packed with these shells. The greater part of the exposure at Nanafalia Landing consists of greensand beds filled with *Gryphœa thirsœ* and other forms, the first named making perhaps 90 per cent. of the whole.

Third. Below the *Gryphœa thirsœ* beds follow some eighty feet or more of sandy clays and sands, variously interstratified, cross-bedded sands passing near the base of the division into greensands which overlie a bed of lignite varying from four to seven feet in thickness.

It is easily possible to obtain overlapping sections which embrace the whole series of about two hundred feet; thus in the bluff at Gullette's Landing, on the Alabama river, nearly the whole of the two upper divisions are represented, while

on Pursley creek, a few miles eastward, the lower part of the second division and the whole of the third are shown in direct contact, the whole series being represented at two localities.

Between the heavy bedded, sandy clays exposed at the base of the Lower Peach Tree Bluff and those which are seen at the top of the bluff at Gullette's Landing there is a series of glauconitic clays and clayey sands which have a tendency to harden into pretty firm rocks, having a striking resemblance to some of the materials of the Buhrstone formation, but which are readily distinguished from the latter by one familiar with both of them. These rocks are shown in the hills which rise immediately back of Gullette's Landing and Black's Bluff (Alabama river) to the height of two hundred and fifty to three hundred feet above the river level, and they are seen again in the Grampian Hills of Wilcox county. We have not as yet been able to connect the beds at Lower Peach Tree with those at Gullette's Landing by an overlapping section which includes a part of each, and there is therefore a little uncertainty as to the precise thickness of these beds, though none as to their quality. There is very little doubt that the lower beds of the Lower Peach Tree Bluff are exposed in the hills back of Gullette's Landing and Black's Bluff, but, as already said, this identity is not absolutely made out. The uncertainty, however, cannot concern more than twenty or thirty feet of strata, if so much. Still, it is much to be regretted that even this slight hiatus exists, since from the top of the White Limestone down to this point every foot of the strata has been exhibited in overlapping sections, so that there is not the slightest room for doubt as to their relative position or thickness, nor is there any room for doubt as to relative position here, but only as to exact thickness.

Sections.—Before giving the section at Gullette's Bluff Landing, some notes concerning the indurated clays and

sands that immediately overlie the rocks at the last named locality, and which are seen in the Grampian Hills, will serve to bring out their peculiarities, especially the points of resemblance between them and certain of the materials of the Buhrstone.

About three miles south of Camden, in the Grampian Hills, we find the following:

(a) *Section in Grampian Hills, No. 1.*

1. Light colored, argillaceous, sand rock, containing casts of *Cytherea*, *Turritella*, *Voluta*, &c. This passes below into a clayey stratum, which in turn is underlaid by a hard, sandy rock containing many shell casts, particularly of *Turritella Mortoni* Con. .5 feet.
2. Gray, clayey beds, breaking into small angular bits .....5 feet.
3. Ledge of glauconitic, clay rock, sandier below and breaking by joints into large, cuboidal blocks of tolerably hard sandstone, containing also a great number of shell casts.....2 feet.
4. Gray clays resembling those of the Buhrstone, but softer and crumbling more easily ..... .15 feet.
5. Glauconitic sands, indurated, filled with casts of *Gryphæa thirsæ* (*first of the Gryphæa thirsæ beds*).....2 feet.
6. Greensand beds, with perfect shells of *Gryphæa thirsæ*..7 to 8 feet.
7. Dark gray clays .....2 to 3 feet.
8. Yellowish, calcareous sands, with *Gryphæa thirsæ*, *Flabellum*, [illegible], &c.....4 to 5 feet.
9. Beds of [illegible] shells .....1 foot.
10. Yellowish, calcareous sands, with concretionary bowlders, containing [illegible] and casts of other shells.....6 to 8 feet.

Half a mile farther south, other beds overlying No. 1 of the above are seen, as shown below:

(b) *Section in Grampian Hills, No. 2.*

1. Whitish, sandy rock, indurated, containing shell casts.....1 foot.
2. Whitish clay rock. .....1 foot.
3. Hard ledge of sandy rock, with casts of Turritella, Cytherea, &c. 2 feet.
4. Gray clays, indurated, and greatly resembling some of the Buhrstone clays 10 to 15 feet.
5. Ledge of indurated glauconitic clay, the lower 12 or 18 inches of which are sandier and filled with shell casts, mostly of *Turritella Mortoni* Con., same as No. 1 of preceding section. 3 to 4 feet.

6. Gray, crumbling clays, with indurated ledge of hard, glauconitic clay in center ..... 6 feet.
7. Hard ledge of glauconitic clay or sandstone breaking by joints into large cuboidal blocks .....4 feet or more.
8. Laminated gray clays resembling those of the Buhrstone, breaking up into small bits.....12 feet.
9. Glauconitic sands, indurated, containing casts of *Gryphæa thirsæ* in the upper part and perfect shells of the same in the lower part .....1 foot.
10. Greensand, with occasional shells of *Gryphæa thirsæ*.....5 feet.
11. Yellowish sand filled with shells of *Gryphæa thirsæ*.....1 foot.
12. Laminated, yellowish sands, with shells of *Gryphæa thirsæ*..4 feet.

The relations between these two sections and the others which exhibit the same strata are more clearly seen in Plate XXIV, Fig. 2, which is a representation of the two preceding profiles combined.

The Grampian Hills extend westward to the river at the Lookout, which is a cliff reaching fully 275 feet above the river level. This cliff is a half a mile or more above Gullette's Landing, and its lower half the beds which make the bluff at Gullette's Landing are exposed by a landslide in a perpendicular section of nearly 150 feet. Above this a very steep, almost precipitous hill rises 125 feet higher. In this upper part of the hill the rocks are not clearly exposed, but they consist of gray, laminated clays, interstratified with heavy bedded, massive clays, such as are seen in the lower part of the Lower Peach Tree Bluff, with which they are probably, in part at least, identical. No fossils were discovered in these clays, which include in places indurated bowlders of calcareous sand. In the lower part of the hill, hard, glauconitic, sandy clays with shell casts are abundant and correspond in position, as well as in other respects, to those represented in the upper members of the two preceding sections.

At Gullette's Landing a cut has been made for the cotton slide and tramway down to the river level through the strata of the bluff, which are thus very clearly exposed almost as if in a vertical wall.

(c) *Section at Gullette's Landing, Alabama River.* (*Plate XXIV, Fig. 1.*)

1. Lafayette sands and loam.....10 feet.
2. Indurated, glauconitic clay, forming ledge..... 3 feet.
3. Gray, sandy clays, thinly laminated and heavy bedded alternating .....12 feet.
4. Glauconitic sand, very green in places..... 2 feet.
5. Gray and sandy clays, like No. 3.....20 feet.
6. Glauconitic, sandy ledge, fossiliferous (*the first of the Gryphæa thirsæ beds*) ..... 3 feet.
7. Compact, yellowish sands holding *Gryphæa thirsæ*, and forming a vertical cliff, capped with an indurated ledge a foot in thickness.....13 feet.
8. Indurated sandy ledge..... 2 feet.
9. White, cross bedded sands.....12 feet.
10. Bluish sands, forming a vertical cliff. These contain numbers of *Gryphæa thirsæ* and have an indurated ledge in the middle of the bed, and one at the bottom.....20 feet.
11. Bluish, clayey sands containing a few *Gryphæa*.....10 feet.
12. Sand containing *Gryphæa thirsæ*, traversed by several indurated projecting ledges; materials are of darker color and more clayey to water level.....20 feet.

At Black's Bluff, Alabama River, about a mile or less below Gullette's Landing, there is a similar section, which, however, is not so clearly exposed. Above the warehouse at this landing, the strata are the same as those at the top of the bluff at Gullette's Landing, but there have been many landslides, by which the relative thickness and positions of the beds here are obscured. Between these two places the river flows approximately along the strike of the strata, which, however, do not lie horizontal, but show one or two undulations with twenty or thirty feet wave height.

The actual contact of the strata of the Bell's Landing and the Nanafalia series fails to appear in the bluffs of the Tombigbee River also, as may be seen in what follows. From Barney's Upper Landing, described in the preceding section, up to the mouth of Horse Creek, no Tertiary beds appear in the river banks. Just above the mouth of this creek grayish, sandy clays occur similar to those which

make up the lower 50 feet of the Lower Peach Tree Bluff, and these clays may be traced foot by foot up the river or northward to Williams's Gin, half a mile or so from Gay's Landing, where they are seen overlying the first of the beds holding *Gryphæa thirsæ*. A section of these strata is given below. (See Plate XXIV, Fig. 4.)

The grayish, sandy clays which overlie these Gryphæa beds are undoubtedly the same as those at Lower Peach Tree, but here also the exact thickness cannot be measured because of their failure to appear in the banks of the river. Still, unless in this short distance of less than a mile there is a fault or a very violent, decided change in the dip of the strata, the thickness of the beds not exposed on the river cannot be much more than fifty feet, if so much.

The strata exposed at Williams's Gin and along the river for half a mile up to Gay's Landing are as follows (see Plate XXIV, Fig. 4.)

(*d*) *Section from Williams's Gin to Gay's Landing, Tombigbee River.*

1. Gray, sandy clays, thin bedded, reddish on joint planes, passing below into an indurated ledge of lighter color.....8 feet.
   About 20 feet more of similar sandy clays appear in the banks of the river, between the mouth of Horse Creek and Williams's Gin, as above mentioned, making the whole thickness actually exposed on this river, between the top of the Gryphæa beds and the bottom of the Bell's Landing marl at Barney's Upper Landing, about thirty feet.*
2. Indurated, glauconitic bed, with *Gryphæa thirsæ*.....2 feet.
3. Dark blue, nearly black, jointed clays, with thin, hard ledges, 6 ft.
4. Indurated, sandy, fossiliferous bed, with a few *Gryphæa* and other forms.....2 to 3 feet.
5. Bluish black clays, with ferruginous concretions at base..3 feet.
6. Greensand bed, with *Gryphæa thirsæ* to water.....3 feet.

Above Gay's Landing there is a long stretch of several miles in which no Tertiary rocks show on the river banks;

*In bed No. 1 above I found a specimen of *Voluta Newcombiana* Whitfield, which heretofore was seen only in the Bell's Landing marl bed and which seemed to be characteristic of it.—E. A. S.

but at Lott's Ferry the Gryphæa beds make their appearance again and may be followed thence without material interruption to Eureka Landing and to Nanafalia, a distance in all of perhaps two miles.

(*e*) *Section at Lott's Ferry, Tombigbee River.* (*Plate XXIV, Fig. 4.*)

1. Dark gray, nearly black, sandy clay, weathering light gray, containing a few fossils ..... 5 feet.
2. Indurated, sandy marl, containing *Gryphæa* in places. This bed varies, being in part a cross-bedded sand devoid of fossils, 3 ft.
3. Dark, sandy clays, with a very few badly preserved fossils, 2 to 3 ft.
4. Glauconitic, sandy beds, with *Gryphæa thirsæ*. This bed is only a few feet thick at Lott's Ferry, but just above shows 20 to 30 ft.

All the Tertiary beds about Lott's Ferry exhibit decided undulations. Bed No. 4 of the preceding section sinks entirely below the water and rises again 20 feet or more above it within the distance of a few hundred yards. All these beds probably overlie the section at Nanafalia below given.

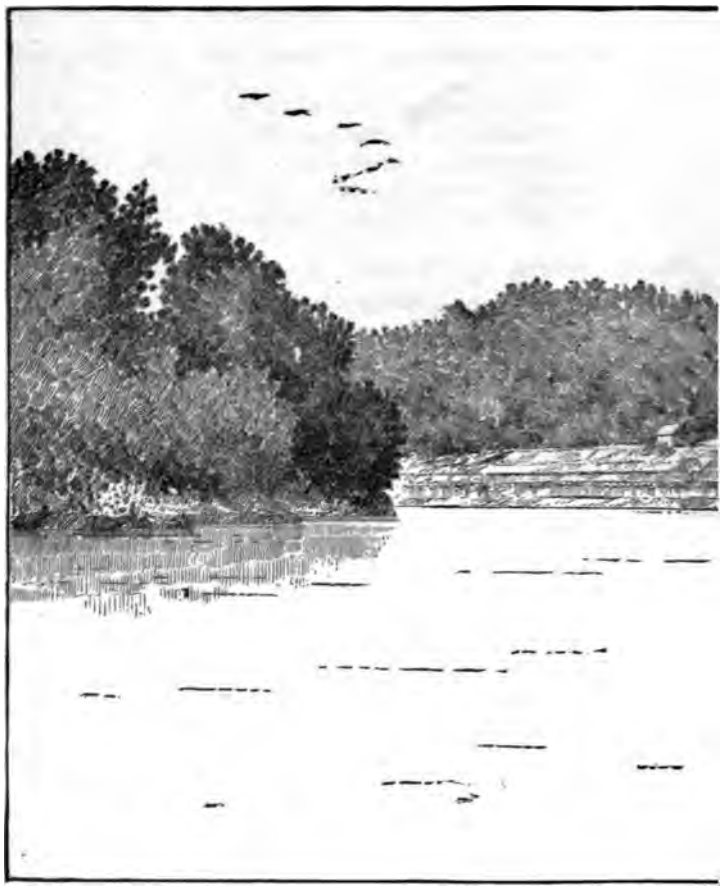
At Eureka Landing there are some 20 to 25 feet of a glauconitic, sandy marl (probably the same as part of the upper bed at Nanafalia) filled with *Gryphœa thirsœ*, associated with very few other forms. This makes a tolerably firm rock, which appears in vertical bluffs, usually capped by hard ledges of the same material, and these ledges are mostly strongly phosphatic.*

At Nanafalia we have the lowermost of the Gryphæa beds, as shown in the following section:

(*f*) *Section at Nanafalia Landing, Tombigbee River.* (*Plate XXIV, Fig. 4.*)

1. Greensand marl, highly fossiliferous, containing chiefly *Gryphæa thirsæ* Gabb, but holding also *Turritelli Mortoni* Con., *Flabellum*, and a few other fossils. This marl makes a tolerably firm rock, with a line of indurated, projecting bowlder-like masses 12 to

*Specimens of the indurated ledges of the *Gryphæa thirsæ* beds from Nanafalia and Eureka Landing, collected in 1884 by Mr. Langdon, proves to be very decidedly phosphatic; one of the specimens analyzed quantitatively contained 6.7 per cent. of phosphoric acid.



NANAFALIA LAN

OCMULGEE RIVER.

18 inches thick of nearly similar material along the whole length of the bluff and near the middle of the bed..about 20 ft.

2. Dark blue, almost black, laminated clay, devoid of fossils, but passing below gradually into a bluish marl..... .....3 to 4 feet.
3. Bluish greensand marl, with a few shells in the upper 3 or 4 feet, but more highly fossiliferous below. This bed contains a great variety of beautifully preserved and easily detached fossils. The fossils can be collected only during very low stages of the water.....8 to 10 feet.

The view (Plate X) shows clearly the greensand No. 1, with its line of indurated bowlders along the center. The large rocks in foreground are part of this indurated marl.

The Nanafalia marl, like that of Wood's Bluff, is one of our most important geological landmarks, both because of its tendency to form by induration tolerably firm and weather resisting rocks and because of the influence which it exerts upon the soils. If there were any doubt as to the agricultural value of either the Wood's Bluff or the Nanafalia marls, it would be dispelled by an inspection of the fertile, naturally marled soils produced where these beds come to the surface across the country.

About 60 feet below the lowermost of the beds containing *Gryphœa thirsœ*, above described, there is an important bed of lignite, which shows a thickness of 4 feet at Coal Bluff, on the Alabama River, and of 7 feet at Landrum's Creek, in Marengo county, near Nanafalia Landing. This lignite appears also at many localities in Marengo and Wilcox counties, e. g., near Shiloh, Magnolia, Hampden, &c., always in connection with the Gryphæa beds, the latter on the summits of the hills, the former 60 feet below in the branches; and, as the Gryphæa marl usually produces very characteristic limy soils, it is not difficult to trace it, as well as the lignite, across the country.

Between the Gryphæa beds and the lignite, the strata are chiefly sands, mostly glauconitic, alternating with sandy clays of grayish colors. The greensands when weathered

appear as yellowish or ferruginous sands, and this is the prevailing color upon the hills, while some shade of green or blue characterizes them near the drainage level, where oxidation is less complete. None of these beds are seen on the immediate banks of the Tombigbee River, and only about 30 feet immediately overlying the lignite occur on the banks of the Alabama; but they may all be seen in direct superposition in the hills which border Pursley Creek on the south, where they are laid bare by the road leading from Black's Bluff to Camden.

This section is complete, as may be seen below.

(*g*) *Section on Pursley Creek, Wilcox county.* (*Plate XXIV, Fig. 3.*)

1. Drift and loam and other beds, much weathered and not further particularized ..... 10 to 15 feet.
2. Dark colored, crumbling clays ..... 5 feet.
3. Sands containing *Gryphæa thirsæ* and a few other fossils .... 5 feet.
4. Thin bedded sands and sandy clays, partly glauconitic, with a few obscure fossils ..... 15 to 20 feet.
5. Yellowish gray, cross-bedded sands, with concretionary bowlders of the same material. These sands hold also at intervals lenticular sheets of gray clay ..... 25 to 30 feet.
6. Interstratified sands and clays, of grayish color with a shade of yellow, rather thin bedded ..... 10 to 15 feet.
7. Gray, sandy clays, exposed in the immediate banks of Pursley Creek below the bridge ..... 6 to 8 feet.
8. Lignitic clay, thickness not determined.

Along the Alabama river no Tertiary strata are to be seen from near Gullette's Bluff to the mouth of Pursley creek. Just above the last named point, however, there is continuous exposure of these strata up to Coal Bluff, as shown in the following:

(*h*) *Section between mouth of Pursley Creek and Coal Bluff.* (*Plate XXIV, Fig. 1.*)

1. Greensand at mouth of Pursley creek ..... 5 feet.
2. Sands, with an indurated ledge one foot thick at top ..... 3 feet.
3. Laminated, clayey sands, with a hard projecting ledge at top and one or two lower ones ..... 6 feet.

4. Indurated greensand, forming a ledge.....3 feet.
5. Greensand of softer texture, easily washed out by the waters and forming shallow caves below the preceding.....5 feet.
6. Greensand of firm texture, with a bed of brownish sand one foot thick at the base.....8 feet.
7. Lignite of Coal Bluff .....4 feet.
8. Firm, sandy clays appearing just above the Coal Bluff Landing .....10 feet.

These beds, as exposed on Landrum's creek (Sec. 23, T. 14, R. 2 E.) are as follows:

(*i*) *Section on Landrum's Creek, Marengo County. (Plate XXIV, Fig. 4.)*

1. Bluish green, micaceous sands.....12 to 15 feet.
2. Lignite.....7 feet.
3. Dark gray, sandy clay.....2 feet.

The lignite here also is 60 feet, by barometric measurement, below the lowermost of the Gyphæa beds, which may be seen on all the hills in the vicinity, where they produce limy soils of great fertility. In most of these limy soils are embedded rounded or water worn fragments of indurated marl.

In many places in Marengo county and elsewhere the greensands overlying the lignite are thoroughly oxidized into a brown iron ore. This may be seen near Magnolia, near Hampden, and near Dumas' Store.

The indurated Grampian Hills rock or *pseudo-buhrstone* as we have been accustomed to call it, does not appear very far west of the Alabama river, but towards the east it becomes very characteristic, especially through Wilcox and Butler counties. It the former county, as may be seen by the map, its outcrop covers a wide area, and the same is true of Butler. Beyond Butler it becomes still more important, or at least its outcrop is nearly ten miles wide through Coffee, Pike and Barbour counties, and at the Chattahoochee river the estimated thickness is not much if anything less than on the Alabama. Many details of the Nanafalia will be

given in the county descriptions of Choctaw, Marengo, Wilcox and Butler, and in Mr. Langdon's paper are given the particulars of its occurrences to the eastward of Butler. In this eastern part of the State it is only the Grampian or *pseudo-buhrstone* phase of the formations that makes any impression upon the topography of the country. Mr. Langdon describes sections of this formation below Spier's bridge on Conecuh river in Crenshaw, in the southeastern part of Pike, and in the northwestern part of Dale, and lastly at Fort Gaines and along the Chattahoochee river below that place.

Useful materials.—There are three materials in the Nanafalia section that have some economic value, viz: the bed of marl, the hard pseudo-buhrstone, and the Coal Bluff lignite. The effects of the marl may be seen at very many places, especially in Marengo and Wilcox, and I might also add Choctaw where it crops out upon the surface and mingles with the sandy loam soil. In all such places the timber growth as well as the undergrowth give evidence of great fertility. There is no question that if applied to the soil by the hand of man the effects would be the same. In the county descriptions these outcrops will be noticed more in detail.

The hard sandstone above mentioned makes a very fair rough building stone and is used at many points for the construction of chimneys.

The Coal Bluff Lignite is four feet thick on the Alabama river and seven feet on Landrum's creek near the Tombigbee, and it holds its average all across Marengo. This might be used as a fuel, although it is pretty high in ash. This lignite from Landrum's creek has been analyzed by Dr. Wm. B. Phillips, with the following results:

Analysis of Landrum's Creek Lignite.

Moisture	13.60
Volatile combustible matter	41.40
Fixed carbon	35.90
Ash	9.10
	100.00

Sulpher, 3.43.

The difficulty in the use of lignite lies in the circumstance that it crumbles upon drying. If this trouble were overcome, the lignites might be used in many places, and this is about the best bed of it in this part of the State, as regards location, thickness and persistence.

E. The Naheola and Matthews' Landing Series.

The strata which make up this series are mostly gray sandy clays alternating with cross-bedded sands, with a bed at the base of the section containing marine fossils, and consisting of glauconitic sands and dark gray, nearly black, sandy clays. The thickness of these strata varies from west to east, being 150 feet or more on the Tombigbee river, and not more than 125 or 130 at Oak Hill, in Wilcox county.

In 1883 we failed to establish the identity of the Naheola marl on the Tombigbee with that of Matthews' Landing on the Alabama, for the reason that at the former place the upper part of the marl is most conspicuous, and was the only part examined by us, while at Matthews' the bluff is made up of the black or dark gray sandy clays which form the lower part of the marl bed. In the summer of 1886 I made a re-examination of the exposures along the Tombigbee river, and found at Naheola the black, clayey marl, identical both in material and in fossil contents with that of Matthews'.

Sections.—On the Tombigbee river there are no Tertiary rocks exposed in the river bluffs between Nanafalia, which lies near the base of the preceding section, and the mouth of

Beaver creek, a distance of about four miles. With an assumed uniform dip of some 30 feet to the mile, this would indicate a thickness of about 120 feet of strata, but from the undulations seen at Lott's Ferry (below Nanafalia) and elsewhere along this river, it is known that the dip is not uniform, and the thickness of the missing beds is probably less than the estimated 120 feet.

From the mouth of Beaver Creek to Naheola there is an almost continuous exposure of Tertiary rocks along the river bank, embracing about 80 feet of strata, making, with the 120 feet estimated above, 200 feet intervening between the base of the Nanafalia marl and the top of the Naheola marl. Of these 200 feet we know from exposures on Landrum's Creek, in Marengo county, and on Pursley Creek, in Wilcox county, the uppermost 60 feet (viz., from the base of the Nanafalia marl down to Coal Bluff lignite), while at Oak Hill (see below) we have a clear profile embracing at least 130 feet immediately overlying the Naheola marl. This would leave about 10 feet of unknown beds at the top of our Naheola section, and it is altogether probable that the Pursley Creek and Oak Hill sections embrace the entire series.

The strata which make all the bluffs between the mouth of Beaver Creek and Naheola, as well as the upper part of the bluff at the last named place, consist, in descending order, of about 20 feet of coarse-grained micaceous sands, with projecting, indurated bowlders of sandstone (no fossils observed), with thin clay partings at intervals; below these, about 10 feet of strongly cross bedded sands, seen in the bluffs just below Tompkinsville, and underlying this to Naheola, laminated sandy clays traversed by layers of lighter colored, sandier, and indurated materials; no fossils observed. It is difficult to give a close estimate of the thickness of these last named beds, but it is not less than 50 or 60 feet, and may be 80.

The section (see Plate XXV, Fig. 3), represents the succession and quality of the beds along this stretch of the river.

The lowest of these sandy clays are seen at the top of the bluff at Naheola, a few miles above Tomkinsville, where they are underlaid by a marl, and black shaly clays at Naheola, as shown in the following section:

(*a*) *Section at Naheola, Tombigbee River. Sec. 31, T. 15, R. 1 E. (Plate XXV, Fig. 3.)*

1. Laminated, gray, sandy clays, with two or three indurated ledges eight to ten inches thick, of lighter colored, sandier materials ..... 18 to 20 feet.
2. Ledge of greensand, oxidized into a brown iron ore of irregular thickness ..... 3 to 6 inches.
3. Black, shaly, sandy clay ..... 3 feet.
4. Ledge like No. 2, of irregular thickness ..... 6 inches.
5. Greensand marl, the upper part indurated, forming a kind of limestone. Both the indurated marl and the limonite, or oxidized greensand above it, hold fossils, prominent among which are an *Arca*, a *Venus*, *Pectunculus Broderipii* Lea, *Turritella Mortoni* Con., *Cardita alticosta* Con., and *Venericardi rotunda* Lea, *Rostellaria trinodifera*, &c. All these fossils are badly preserved. Thickness of bed ..... about 3 feet.*
6. Black, slaty clay like that occurring on the river above this point to Black Bluff ..... 10 to 15 feet.

Half a mile or so below Naheola, just below Marengo Chute, the marl bed No. 5 occurs at the water level, and at Kemp's Landing, a short distance above Naheola, the marl, with its overlying ferruginous concretions, is again seen.

On the Alabama River the Tertiary beds, corresponding to those just described in the vicinity of Tompkinsville, oc-

*During the summer of 1886 this bed was more closely examined than in 1883, with the result of finding in its lower part a great number of the characteristic Matthews's Landing fossils. Wherever this bed has been exposed to the weather it crumbles down, liberating the shells exactly as at the last-named locality. In 1883 our attention was confined to the upper part of the Naheola bed, with its badly-preserved shells in a greensand matrix; and thus the identity of this bed with that at Matthews's Landing was so clearly seen.

cur between Coal Bluff and Clifton, a distance, by the river, of 10 or 12 miles. On this river there are many interruptions in the continuity of the Tertiary bluffs, so that it would be impossible, from the exposures along the river alone, to get any clear idea of the stratigraphy. All this, however, is made good, as will be seen above, in the sections obtained at Oak Hill and on Pine Barren Creek, in eastern Wilcox county.

The Tertiary beds make the bluffs of the Alabama River at a few localities mentioned below and exhibited in Plate XXV, Fig. 2.

At Burford's Landing, NW.$\frac{1}{4}$ of Sec. 5, T. 11, R. 7 E., and just above it in Sec. 32, T. 12, R. 7 E., there are low bluffs of laminated and cross bedded sands, alternating with thin seams of gray clay.

At Walnut Bluff, below the mouth of Turkey Creek, the banks are of light colored, yellowish, cross bedded sands, and above Turkey Creek a laminated, sandy clay like so much of the material occurring about Tompkinsville. These clays are devoid of fossils and continue up to Clifton, with very variable dip, the beds being sometimes horizontal, sometimes strongly inclined (nearly one foot in ten), but the average dip is much less, probably somewhere near one in two hundred. It thus becomes very difficult to sum up the thickness of these sandy clays, both because of variable dip and because the bluffs are not continuous.

At Clifton the bluff is 75 feet or more in height, the greater part of the slope being of Lafayette sands, &c., while the Tertiary clays at the base of the hill are only about 10 feet in thickness.

About one mile above Clifton, on the left bank of the river, there is a low bluff of black clays, which extends about a mile up the river. These clays have not been closely examined, but they appear quite similar to those seen higher up, at the mouth of Dickson's Creek, where a bluish black, micaceous,

sandy clay, holding many finely preserved fossils, forms the right bank of the river. This is the same bed as that which makes the top of the bluff at Matthews's Landing, a mile or two higher up the river, where we get the following good section of this important deposit:

(*b*) *Section at Matthews's Landing, Alabama River, northern part of Sec. 12, T. 12, R. 6 E.* (*Plate XXV, Fig. 3.*)

1. Bluish or greenish black, micaceous, clayey sand, with finely preserved fossils, very dark when wet, but becoming grayish blue on drying; crumbles upon exposed slopes, liberating the fossils, which lie in the crumbs thus produced. This is capped by an indurated, sandy, concretionary ledge.* The thickness of the marl deposit is .....about 5 to 6 feet.
2. Gray sands with a slightly yellowish cast, showing a great tendency to indurate into lens-shaped bowlders, 1 to 2 feet thick and 3 to 4 feet wide. The sands are also fossiliferous, but much less so than the preceding; the fossils are difficult to get out because of the hardness of the material.....3 to 4 feet.
3. Bluish, micaceous, clayey sand, much like No. 1, but not holding all of its characteristic fossils. Where this stratum lies exposed to the sun and weather upon flat or nearly horizontal benches, it disintegrates, like No. 1, into crumbs, in which the liberated fossils lie loosely, but where it forms vertical bluffs, it is firm and compact and resembles black clay.....7 to 8 feet.

This lowermost bed is sandy above and clayey below, and the material of the whole bluff might be better described as a bluish black, sandy clay, divided into two parts by a bed of calcareous sand, which reaches up into the upper clay bed and down into the lower by gradual transition. The beds which compose this bluff are seen along the river for a mile or more, and are approximately horizontal in position, since the river in this part of its course runs in the direction of the strike of the beds.

The Matthews's Landing marl bed is seen eastward of the Alabama River at very many places in Wilcox county, and it holds usually a number of well-preserved fossils. Near

*This is probably one of the glauconitic, concretion-forming sands which are so characteristic of the marl of Naheola.

Mr. Clarence Jones's, 7 miles east of Camden, on the Allenton road, there are a good many exposures of this marl bed in the gullies, and we get a very fair section of some 30 feet of the underlying rock. At Oak Hill and in Dale's Branch (see below) we have other good outcrops of the marl. The consideration of this fine section, which includes also the underlying beds down to the base of the Tertiary, we shall leave till after the description of the occurrences along the two rivers.

F. The Black Bluff or Sucarnochee Series.

This section has been named from its most characteristic exposure at Black Bluff, on the Tombigbee River, in Sec. 12, T. 16, R. 1 W., in Sumter county, which is as follows:

(*a*) *Section at Black Bluff, Tombigbee River.* (*Plate XXV, Fig. 3.*)

1. Yellowish clay, which makes the basis of the Flatwoods, occupying top of bluff ..... about 20 to 25 feet.
2. Black, slaty clay, fossiliferous ..... 40 feet.
3. Brownish shale or clay to water level ..... 8 to 10 feet.

The black clay, No. 2, contains marine fossils, the most prominent among which are a little coral, an Arca, fragments of the shells of a large Nautilus, parts of crabs, &c.

The lower part of the bluff at this place is covered with singularly shaped concretionary masses of limonite. The surfaces of these concretions are marked off into rhomboidal plates, like the markings on an alligator's skin. The shales or black clays are strongly calcareous, which accounts for the limy character of some of the soils derived from them in Marengo and Wilcox counties.

In Sumter county a bed of lignite is found near the summit of the black clays, and just beneath the yellowish clays of the above section.

All the bluffs from Black Bluff down to Naheola, above described, are composed of a black clay in most respects similar to No. 2 of the above section.

The fossiliferous bed of Black Bluff may be seen at any of the exposures as far down the river as Griffin's Landing, 7 or 8 miles, nearly along the strike of the strata. Below Griffin's, down to Naheola, the black clay of the bluffs is quite hard and compact; breaking with conchoidal fracture and resembling very closely the black shale of the Devonian formation. No trace of a fossil could be detected in the black clay along this long stretch of the river. At Lewis's Lower Landing, Beckley's, Oakchai, Steiner's, Kemp's, and Naheola the clays are usually covered with the singular limonite concretions remarked upon at Black Bluff.

The distance across the strike of the rocks, from Black Bluff to Naheola, is 7 or 8 miles, and through this distance the only Tertiary rocks which appear on the river banks are black clays. Upon the assumption that the dip of these rocks is uniformly about 30 feet to the mile, this would indicate a thickness of nearly 200 feet. But we have seen above that undulations are not rare in the Tertiary rocks, so that the actual thickness is probably very considerably less than 200 feet. The Bladen Springs boring (Plate XXVIII, column 4), shows, according to our interpretation of it, only about 100 feet of black clays above the Rotten Limestone, and a part of this may belong to the Ripley group of the Cretaceous.

As to the equivalence of this black clay group, there is no doubt that it in part represents the Flatwoods group of Dr. Hilgard, because these Flatwoods, so well developed in Mississippi, extend down into Sumter county, in Alabama, and across it to the Tombigbee, and thence across Marengo to the Alabama, which they touch at Midway, a short distance below Prairie Bluff.

In Sumter, Marengo, and in Wilcox west of the Alabama river, these clays are the typical Flatwoods clays giving origin to stiff clay soils with comparatively little lime.

Eastward of the Alabama river there are no genuine Flat-

woods. Even in Marengo county the lower portions of the Black Bluff clays become quite limy and the Flatwoods belt along its northern border, below Dayton and eastward, shows a strip of regular black prairie soils similar to those of the Rotten Limestone and passing, by almost imperceptible gradations, into the Flatwoods. At Prairie Bluff this limy border of the Flatwoods is a mile or two in width but north of it come the regular post oak Flatwoods.

Across the river, however, the whole formation becomes more calcareous, the lower part continuing to form a belt of black prairie clay soils, on Prairie Creek and Pine Barren, while the upper parts pass into sandy calcareous beds and sandy limestones, which bear a very strong resemblance to some of the beds of the Cretaceous.

Both the upper sandy beds and the lower clayey beds are well seen near Allenton in the eastern part of the county, and in the adjoining parts of Butler.

Near Allenton and Oak Hill in Wilcox county and along the hill slope leading down to Pine Barren creek, it is possible to get continuous sections of the lower strata of the Lignitic together with the underlying Clayton or Midway division down to the Ripley beds of the Cretaceous.

These sections are here presented as supplementary to and confirmatory of those derived from the study of the river bluffs.

THE OAK HILL AND PINE BARREN PROFILE.

This profile embraces the strata of the Naheola or Matthews's Landing, and the Black Bluff, sections above described, and of the Midway or Clayton section to be mentioned below, and gives us a continuous view of all the strata from just below the Coal Bluff lignite down to and including the uppermost beds of the Cretaceous. Our three lowest sections of the Lignitic might with propriety be classed together as the Oak Hill-Pine Barren group.

About half a mile to three-quarters west of Oak Hill, in Sec. 16, T. 11, R. 10 E., in Wilcox county, the Allenton and Camden road descends a long hill, where at least 150 feet of the Tertiary strata are laid bare.

(*a*) *Section near Oak Hill, Wilcox County.* (*Plate XXV.*)

Red loam, pebbles, &c., of the Drift.

1. Cross bedded sands and thinly laminated clays, much decayed and difficult at times to distinguish from the overlying red loam ..... 25 feet.
2. Gray cross bedded sands, alternating with thin laminæ of gray clay; general aspect of the whole, gray..... 40 feet.
3. Bed of yellowish gray, cross bedded, and laminated sand. 18 inches.
4. Thinly bedded, gray clays, interstratified with thin ledges of cross bedded sands..... 30 feet.
5. Sands 1 foot; clays 1 foot; sands 1 foot..... 3 feet.
6. Gray clays, interstratified with cross bedded sands..... 6 feet.
7. Gray, cross bedded sands with very little clay..... 3 feet.
8. Gray clay breaking up into cuboidal blocks, interstratified with sandy ledges..... 15 feet.
9. Black to gray micaceous sands, with the fossils of Matthews's Landing..... 7 feet.

   This bed is darker at top and lighter colored at bottom. In Dale's Branch, close by, the same bed occurs with glauconite in part of it. It is quite possible that part of this bed may be identical with the Naheola marl. At other localities, near Oak Hill, this bed has a greater thickness, and the above may be taken as the lower limit. According to the observations of Mr. Johnson, in a well bored at W. W. McConnico's the thickness goes even to 20 feet, thus approximating the thickness at Matthews's Landing.
10. Hard ledge of calcareous glauconitic sand..... 1 foot.
11. Yellowish calcareous sands, with white lime concretions and one or two harder ledges..... 12 feet.
12. Glauconitic sands with indurated ledge at top..... 10 feet.
13. Sandy shales, with indurated ledge..... 5 feet.
14. Hard, yellowish, sandy limestone, with phosphatic nodules, appearing also in the Graveyard Hill section, No. 3.... 2 to 3 feet.

This bed is a very conspicuous feature in all this vicinity; it may be seen on the sides and summits of most of the low hills, where, breaking off in consequence of joint planes, it

appears like a low stone wall running around the hills. From the locality above given to the Graveyard Hill this stratum can be followed with certainty, and appears as above stated in the accompanying section:

(b) Section on Graveyard Hill. (Sec. 5, T. 11, R. 10 E.)

1. Grayish white, calcareous sand, with small phosphatic nodules, characterized by an abundance of crustacean remains...5 feet.
2. Whitish, calcareous sands, with several harder ledges which shale off in weathering .....20 feet.
3. Hard, yellowish, sandy limestone, containing small phosphatic nodules. This is the rock which forms the walls around all the low hills in the vicinity.....2 to 3 feet.
4. Yellowish, calcareous, clayey sand, with white lime concretions, becoming grayer in color and more clayey, and containing numerous fossils identical with those found at Black Bluff. 15 feet.
5. Black, calcareous clays, yellowish gray on weathered surfaces, also containing the Black Bluff fossils, but less abundantly than the preceding bed.....20 feet or more.

This black clay and the overlying bed yield the prairie soils of this section of Wilcox county. These soils are exceedingly fertile, as may be seen by the fine crops which grow upon them and by the immense height of the weeds which spring up by the roadsides.

Graveyard Hill, like the others in the vicinity, slopes off into the prairie fields which border Prairie and Pine Barren Creeks. In the lower parts of these fields we come always upon a ledge of rocks described below, which forms the continuation of the section above given. Below this rocky ledge occur sands and sandy shales, which undoubtedly belong to the Cretaceous formation.

The whole thickness of the clays, &c., which form the prairies here is about 30 to 35 feet, so that what follows is only the direct continuation of the preceding section.

The above sections (a and b) exhibit the lower strata of the Lignitic down to its base. For the sake of continuity, the following section from the Graveyard hill down to Pine

Barren creek is here introduced, although it includes the strata of the Clayton division, to be more specifically described below. This section shows also the contact of this lowermost of the Tertiary strata with the uppermost of the Cretaceous.

(c) *Section from base of Graveyard Hill to Pine Barren Creek.*

Black clays, weathering yellow, basis of prairies, No. 5 of the preceding section.

6. Hard, grayish white limestone, characterized by great numbers of a large *Nautilus* (*Enclimatoceras Ulrichi*), and hence known as the Nautilus Rock.....about 10 feet.
7. Calcareous sands forming basis of the black, sandy prairies of this vicinity .....6 feet.
8. Hard, yellowish white, crystaline lime rock, sandy in places and filled with red specks, highly fossiliferous, containing *Turritella* in great numbers; also *Carditas*, a *Rostellaria*, *Ostrea*, and two or three species of coral. This is one of the most persistent of the lower Tertiary rocks towards the east.....8 feet.
9. Yellowish, micaceous sands, with Cretaceous fossils .....55 feet.
10. Bluish gray, calcareous sands, with two very prominent ledges 4 feet apart, and two or three smaller ledges. Thickness to water level below Palmer's Mill.....15 feet.

These three sections are illustrated in Fig. 1 of Plate XXV.

In the Oak Hill section (a) the strata down to and including the marl bed No. 9 might be considered equivalent to the Naheola and Tompkinsville beds; the Graveyard Hill section (b) is no doubt the equivalent of the Black Bluff section of the Tombigbee River, and the great change in the character of the beds is to be noted. In the place of the black non-calcareous clays which compose the whole section on the Tombigbee, we have here, yellowish and black calcareous clays at the base of the section and light colored calcareous sands and sandy limestones above. In section (c) we have the equivalent of the part of the bluff at Midway (that containing the large Nautilus), while the hard limestone rock has not been identified much to the west of

this locality. It is more than probable that the bed No. 7 of this section is merely the disintegrated part of the No. 6, or Nautilus rock, and it is more than doubtful that it forms a distinct stratum.

The variations in the thickness and other characters of these lowermost liguitic strata observed in going eastward will be given below in connection with the Clayton division.

4 The Clayton (Formerly Midway).

General Characters.—This division was formerly placed with the lignitic under the name of the Midway or Pine Barren section, but because of the great development of the formation in the eastern part of the State, and the absence of any lignite beds in it, the name Clayton has been substituted, from the county seat of Barbour where the limestones and other characteristic beds are so well exposed. The thickness varies from 25 feet along the Alabama river to more than 200 on the Chattahoochee, and the character of the strata also varies greatly in the two sections.

Between Matthews's Landing, above described, and Midway there are no Tertiary rocks exposed along the banks of the Alabama river.

The bluff at Midway is half a mile or more in length, the dip of the strata quite variable, but very considerable, in places as much as one in thirty; and in some places the beds are nearly horizontal. At the lower end of the bluff appear black clays similar to those at Matthews's Landing or Black Bluff, a few feet only showing, and these apparently without fossils. These clays overlie about 10 feet of light colored argillaceous limestone, with projecting hard ledges. This limestone contains the large Nautilus (Enclimatoceras) which characterizes the lowermost Tertiary beds about Pine Barren Creek below mentioned, and it is no doubt identical with the Nautilus rock of eastern Wilcox.

This Nautilus rock has been recognized in that part of

Wilcox county lying west of the Alabama river, and it has been traced thence across Marengo county to Moscow, on the Tombigbee river. Southward of the localities where it forms the surface appears always a strip of black prairie soils, derived from the disintegration of the calcareous clays (of Black Bluff group), which immediately overlie the Nautilus limestone, and southward still of this prairie belt lies the belt of Post-Oak Flatwoods, the soils of which come from the disintegration of the non-calcareous clays of the Black Bluff group. The Flatwoods belt, as has already been intimated, does not appear to extend beyond the Alabama river towards the east, while the prairie belt attains to greater and greater importance in that direction.

Midway is some 4 miles down the river from Prairie Bluff, where occurs the first outcrop of Cretaceous rocks on the Alabama.

Between these two points there are none but comparatively recent deposits along the river banks.

The position and character of the Tertiary rocks exposed at Midway may be seen on Plate XXV, Fig. 2.

Along Pine Barren and Cedar creeks in the eastern parts of Wilcox and adjoining parts of Butler, the white argillaceous limestone with the *Nautilus* or *Enclimatoceras* shells, is from 10 to 40 feet thick, increasing towards the east.

This is underlaid by a hard crystalline limestone 8 or 10 feet in thickness, holding a great number of shells, generally badly preserved, among which the genus *Turritella* is conspicuous, from which circumstance the name Turritella rock is often used in referring to it. Besides the turritellas, there are several species of *venericardia*, *ostrea*, *cerithium*, *rostellaria*, etc., new to science, and therefore described and illustrated by Mr. Aldrich in the paper given below in this report. Mr. Aldrich's notes are mainly based upon a collection made by me in the fall of 1890, although previous

collections had brought together a large number of the fossils of that section.

By the studies of Mr. Aldrich any doubts which may have remained concerning the age of these rocks have been removed, and they are definitely assigned to the lowermost of the Tertiary. The physical and lithological characters of the rocks, however, are strikingly like those of Cretaceous strata.

The fertile lands along this part of Pine Barren creek (in Wilcox county) are based upon the black calcareous clays of the Black Bluff or Sucarnochee group, and upon a black calcareous sand derived from the disintegration of the Nautilus rock. Upon this latter soil the original growth was red cedar, forming what are known in this section as "cedar brakes."

Between Snow Hill and Monterey in Butler county the road lies chiefly over these lowermost strata of the Tertiary, viz., the Nautilus and Turritella rocks, which cap the hills that make the westward continuation of the "Little Texas" region of Lowndes. Where the Nautilus rock forms the surface the soil is a black limy clay soil similar to the prairie soil of the Cretaceous, and supports a timber growth of cedars with some post and chestnut oaks, hickories, ash and hackberry. On nearing Monterey these rocks pass below the Black Bluff series and we have a section exposed very similar to that already given for Oak Hill down to Pine Barren. All these strata about Monterey are strongly impregnated with lime.

Beyond Butler county the strata that can be referred to the Naheola and Sucarnochee sections cannot be made out with any great degree of certainty, since the Lafayette sands cover the face of the country very generally and hide the underlying Tertiaries. On Conecuh river in the eastern part of Crenshaw or southwestern of Pike county, Mr. Langdon finds an outcrop of lignite which from its relations to

the underlying group he thinks must be the Coal Bluff lignite, and similarly in the southeastern part of Pike a lignite outcrop is referred to this horizon. At one or two localities in Pike and Barbour, shell beds with badly preserved forms and belonging to this part of the geological column have been observed, but there are no strata outcropping along the Chattahoochee river which could be interpreted as belonging here.

In the case of this lowermost or Clayton division of the Tertiary, however, we find the thickness and other characters changing in a marked way. From a thickness of twenty-five feet on the Alabama river at Midway Landing we find it increasing in Lowndes and Butler to more than forty feet, beyond which, although the distinction of nautilus or turritella rocks cannot be made, yet the equivalent rock may be followed to the Chattahoochee where its thickness must be at least 200 feet.

The variations in this formation, observed on following it eastward, were first satisfactorily worked out by Mr. Langdon, who describes them in his paper below. In the main the changes are these: beyond the Little Texas region in the northern part of Butler and adjoining parts of Lowndes, the Turritella rock is only about 8-10 feet in thickness while the Nautilus rock attains in places the thickness of fifty or sixty feet. Coming eastward it becomes impossible to follow out the distinction, since nothing very closely resembling either the nautilus or the turritella rock of Wilcox or Lowndes is to be discovered, but instead we find the lowermost of the Tertiary rocks assuming near Rutledge in Crenshaw county the character of a soft white pulverulent limestone more closely resembling the orbitoidal rock of the upper Eocene than anything else. Mr. Langdon says, however, that this particular phase of the rock is confined to that immediate vicinity. Beyond, in Pike county, the equivalent rock is a sandy, cream colored limestone which reaches

very considerable thickness through Pike and Barbour counties, and is massive enough to allow of the formation of caverns, and big springs. The influence of this rock is also very distinctly felt in the soils, and the deep red loams in Pike and Barbour are based upon it. In the vicinity of Clayton this limestone may be seen at many points and it has often been burned for lime. Above the limestone is a stratum of hard massive clays of blue to gray color, which have much the appearance of fire clay, though rather low in specific gravity. A microscopic examination of this material by Mr. Cunningham shows that it is somewhat of the same nature as the light clay-like substance so common in the Buhrstone, being in good part made up of the minute shells of *radiolaria* and the silicious spicules of sponges. Another sample proves to be a *fossil diatomaceous clay* containing also great numbers of fragments of sponge spicules. These tripolis therefore seem to range at least from the Buhrstone down to the base of the Tertiary.

Where the overlying red loam of the Lafayette is in contact with these clays it is usual to find very fair quality of limonite, sometimes of the fibrous or needle ore variety. This ore, however, has not been seen in any very great quantity. In parts of the limestone about Clayton there are great numbers of shells of an oyster (*O. tumidula, Aldr.*) which seems to be characteristic of this horizon. In the county descriptions of Barbour and Pike will be found many details not appropriate here. This rock is well displayed across the river in Georgia, and especially about the town of Cuthbert where it has been quarried for building purposes, and it answers very well for rough work. At the Fort Gaines Bluff it makes the lowermost bed, and Mr. Langdon has pointed out an eroded surface, indicating unconformity, between it and the next overlying beds which probably belong to the Nanafalia section of our Lignitic.

Useful Materials.—In the white limestone of this series

in Marengo county, near Dayton, a number of pockets filled with an indurated bituminous substance resembling coal in general appearance, but differing from coal in its manner of burning and in percentage of ash, have been found.

In some cases this material has been used as a fuel, and Mr. C. C. Shields, near Dayton, got up about a ton of it from one place. The same material has also been seen in this formation a short distance below Eufaula. Analyses of the substance from both these localities, No. 1 from near Dayton, No. 2 from near Eufaula, have been made by Dr. Phillips with the results given below:

Fossil Resins, Marengo and Barbour Counties.

	Proximate analysis.	
	I.	*II.*
Moisture	1.20	0.10
Volatile matters	57.65	62.85
Fixed carbon	41.00	36.20
Ash	.15	.85
	100.00	100.00

The ultimate analysis of the same specimens shows the following composition:

	I.	*II.*
Carbon	63.88	59.86
Hydrogen	9.07	7.90
Oxygen, by difference	20.21	26.17
Nitrogen	0.37	0.63
Sulphur	5.12	4.49
Moisture	1.20	0.10
Ash	.15	.85
	100.00	100.00

This substance burns very freely, with large luminous flame, and if found in any sufficient quantity might be used as a fuel or as a source of illuminating gas. The analyses show that this is a variety of fossil resin, heretofore unde-

scribed, and a very similar substance occurs at many places in the white limestone of the Tertiary formation.

In the northeastern corner of Mississippi and extending thence up partly through the state of Tennessee, a series of strata closely resembling those occurring about Pine Barren creek and in "Little Texas," has recently been described by Dr. J. M. Safford under the name of the *Middleton formation.* This occupies the same geological position as our Clayton, viz., the base of the Tertiary, and is very probably the equivalent of it. Although none of the nautilus shells so common in this formation in the Alabama and Tombigbee drainage areas, were seen in the Middleton rocks, yet Mr. Langdon has identified in the cabinet of the University of Mississippi a specimen of this nautilus (*Enclimatoceras Ulrichi,*) labelled *Nautilus circulus*, Tuomey; the specimen in question being from Tippah county, and therefore presumably from the Middleton series. In the Mississippi geological map this occurrence is noted and assigned to the Buhrstone, on lithological grounds.

Tripoli.—Some of the light porous clays of this formation, for example, those exposed in the railroad cut at Clayton, prove to be tripoli, being in great part composed of the minute shells of diatoms, radiolaria and sponge spicules. It might be worth while to give these things a thorough test as to their commercial value.

Remarks on the Lignitic and Clayton Sections.

It may be remembered that from the summit of the White Limestone down to the base of the Bell's Landing section of Lignitic, representing about 1,200 feet, our geological column is uninterrupted and is covered throughout by overlapping sections.

Below the Bell's Landing section occurs the first hiatus or break in this column, the first place where we have as yet been unable to connect two contiguous divisions by overlapping sections.

Immediately below the Coal Bluff lignite of the preceding section there is a second gap, the exact dimensions of which we have as yet not been able to ascertain. Making the highest estimate (based upon an assumed uniform dip of the strata of 30 feet to the mile), the thickness of the beds here concerned can hardly be more than 50 or 60 feet, for the missing beds should outcrop along the Tombigbee River between Nanafalia Landing and the mouth of Beaver Creek, a distance of 4 miles, corresponding to a thickness of 120 feet. We know, from exposures on Landrum's Creek and Pursley Creek, all the beds below the Nanafalia marl down to the lignite, 60 feet below, so that the missing beds would constitute the other half of this estimated 120 feet.

On the Alabama River, likewise, we see some ten feet of strata below the lignite, after which follows a barren stretch of river bank which shows no Tertiary beds at all for two or three miles.

In the Pine Barren Profile, which gives so complete a view of the lower part of the Tertiary formation, the lignite is not seen in actual contact with the beds in this section, so that here, also, we have the gap unfilled. From the occurrence of the lignite, however, a short distance south of Oak Hill, which makes the summit of the Pine Barren section, the thickness of the beds involved in this gap is here also shown to be not very great, except upon the assumption of a very abrupt change in the dip of the strata, which is wholly unauthorized by any facts which have come under our observation.

Geologically below this gap, from the mouth of Beaver creek, on the Tombigbee, to Black Bluff (up the river), there is an almost continuous exposure of Tertiary beds along the river banks, but there is difficulty in getting the exact thickness of the beds thus exposed.

On the Alabama river the exposures are much less con-

tinuous, and the thickness of the beds correspondingly more difficult to ascertain.

It is therefore fortunate that we have, in the Pine Barren region, a continuous section of 240 or 250 feet, embracing all the beds below the gap or hiatus named, down to the top of the Cretaceous formation.

This section is exposed at two localities above given, viz: Along the Camden road, about half a mile west of Oak Hill, and at the Graveyard Hill in Sec. 8, T. 11, R. 10 E., the lower beds of Oak Hill appearing in the upper part of the Graveyard Hill. The lower portion of the section appears at the base of the latter hill and along the low grounds of Prairie creek down to Palmer's mill on Pine Barren creek. All the lower part of this section, up to the Dale Branch or Matthews's Landing marl, was very carefully worked out in 1883 by Mr. Johnson, and the section continued by estimates up to the Nanafalia beds, which appear at Eggville, in Sec. 22, T. 11, R. 10 E. To Mr. Johnson also belongs the whole credit of determining beyond doubt the exact limit between the Tertiary and Cretaceous rocks in eastern Wilcox.

He has shown that the Nautilus (Enclimatoceras) rock, which had, up to 1883, been considered Cretaceous, overlies a crystalline limestone holding *Turritellas*, *Carditas*, a *Rostellaria*, and other Tertiary species. The measured section from Chambers creek across Pine Barren creek up to the summit of the Graveyard Hill profile (see Plate XXVII, Fig. 1) was also made by him.

In the summer of 1885 these localities were visited by the present writer, when the measured part of Mr. Johnson's section up to the Dale Branch or Matthews's Landing marl was fully verified and extended by the addition of some 125 feet of strata exposed along the Camden road, near Oak Hill, and in direct superposition over the Dale Branch marl. Notwithstanding the 125 feet thus transferred from "esti-

mated" to the firm ground of "measured" strata, there still remains, as above stated, a gap not covered by overlapping sections between the top of the Oak Hill section and the Coal Bluff lignite.

It would be manifestly a serious omission on our part not to speak in this connection of the observations of Prof. Alexander Winchell, made in 1856 in eastern Wilcox county.*

This author recognized as Tertiary, and described in sufficient detail to render their identification easy, several of the beds included in our Pine Barren sections above given, notably No. 3 of the Graveyard Hill and the underlying marls containing Black Bluff fossils, and also the Turritella rock which lies at the base of our Tertiary section, and he rightly extends the line between the Tertiary and Cretaceous to a point eight and a half miles north of Allenton.

These rocks he, however, places in the Buhrstone, and above his Buff Sand, which he considers the lowermost of the Tertiary rocks. By comparing our Nanafalia sections and Professor Winchell's description, it will be seen that his Buff Sand overlies (at Black's Bluff on the Alabama river) the beds with *Gryphæa thirsæ*, which at that time was generally considered a Cretaceous species. These beds we now know are some three hundred feet above the top of the Cretaceous.

Notwithstanding some mistakes in fixing the relative positions of rocks observed at widely distant localities, mistakes which were probably unavoidable without long-continued observations, we find recorded in this pioneer work of Professor Winchell a host of sagacious observations which have been fully confirmed by those who have since gone over the same ground.

In this part of the Tertiary the variations in the thickness of the beds and the quality of the material as we go from

*Proceedings Am. Assoc. Adv. Sci. Part II, pp. 87–89, 1856.

west to east are more striking than in the overlying strata. Thus, on the Tombigbee river, near the base of the Tertiary, there is a great thickness of black, sandy clays (80 feet or more in one place, Black Bluff), which extend down the river for many miles, to Naheola, while on the Alabama the only rocks seen of this kind are at and near Matthews's Landing, which is near the top of the series; and in the Pine Barren section in eastern Wilcox county, where all the strata are shown, the whole thickness, including the Matthews's Landing marl, is not greater than 75 feet.

On account of these differences it becomes impossible, without further comparison, to correlate some of the beds of the Tombigbee section with those exposed at Oak Hill and on Pine Barren creek.

In the vicinity of Palmer's Mill (Smith's bridge), on Pine Barren creek, in Wilcox county, we have the lowermost of the Tertiary beds in direct contact with the uppermost of the Cretaceous. At this place the beds of the two formations appear to be strictly conformable with each other. Here, also, the lower Tertiary beds have a very striking resemblance in lithological characters to some of the Cretaceous beds; but the fossils, as Mr. Johnson has shown, leave no room for doubt as to the age of the beds.

This resemblance is most pronounced in the case of the shaly sandy beds of Graveyard Hill, which might easily be mistaken for similar beds occurring at Canton Landing and back of Prairie Bluff. The latter are of Ripley age, while the Graveyard Hill rock overlies sandy clays holding Black Bluff fossils. So, also, the Nautilus rock might well pass for Cretaceous, except that it overlies a limestone holding Turritellas, Carditas, and other fossils which Mr. Johnson has identified as Tertiary. No one can fail to be impressed with the similarity in general aspect, if not in the organic contents, of the contiguous beds of the two formations.

The Bladen Springs Boring.

In the years 1884 and 1885 a boring was made at Bladen Springs, in Choctaw county, in search of petroleum. The carefully kept record was obtained from Captain Trowbridge who had charge of the boring.

The surface rocks at the place of boring are either the lowermost of the Buhrstone or, more probably, the uppermost of the Hatchetigbee, the loose surface materials hiding the Tertiary rocks at the locality. The boring penetrated through the underlying Tertiary rocks, through the Ripley, and 125 feet (as we interpret it) into the Rotten Limestone of the Cretaceous. We have inserted this record, drawn to scale, in its proper place in the general section (see Plate XXVIII, column 4), where it will be seen the thickness revealed by the boring corresponds very well with that established by our measurements. It is, however, difficult to correlate with any certainty the beds penetrated by the boring with the strata of the general section, since an accurate determination of the lithological and other characters of the beds from the loose and mingled materials brought up by the auger is manifestly impossible; still, we have felt warranted in several instances in pointing out the probable equivalences. In the lower part of the boring, especially, we think that the black or dark blue clays and clayey sands of the Black Bluff and Ripley sections are unmistakably shown, as is also the Rotten Limestone, although in the boring there appear only 17 feet of sands at base of the Ripley, while in some places, as at Prairie Bluff, the thickness is at least 60 feet.

In 1384, while the boring was still in progress, Mr. D. W. Langdon, jr., visited Bladen Springs, and, upon the authority of our then much less perfect river section, predicted that the Rotten Limestone would be reached at 1,200 feet. In reality it was reached at 1,220 feet.

Undulations and Faults in the Tertiary Strata of Alabama.

EOCENE.

The average seaward dip of the Tertiary strata of Alabama is about twenty-five or thirty feet to the mile, but there is at many points a wide departure from this uniformity. Professor Tuomey appears to have been the first to direct attention to this circumstance. In speaking of the Buhrstone at the Lower Salt Works, in Clarke county, he remarks:

> We have here, then, an interesting example of the sinking of strata below the surface and of their rising again. The beds exposed at Baker's Bluff, and still higher on the river, as well as on Bashi Creek, after being depressed beneath Saint Stephens and a portion of Clarke county, make their appearance again at this locality, and probably still further west.*

As intimated in another part of the present publication, these observations of Professor Tuomey were confirmed by us in 1883, and my subsequent investigations have further shown the existence of more than one well marked fold in the strata of this part of the state.

On another page we have said that the Buhrstone rocks which dip below the surface a short distance south of Wood's Bluff, in Clarke county, rise again at Hatchetigbee Bluff and at Jackson, and from this latter place an almost continuous outcrop of these rocks may be followed southward as far as the Lower Salt Works. These points appear to mark the summits of at least two distinct anticlines, and a third is marked by Lower Peach Tree, on the Alabama River, while the unequal surface distribution of the beds of the Lignitic formation, lying to the northward of the localities

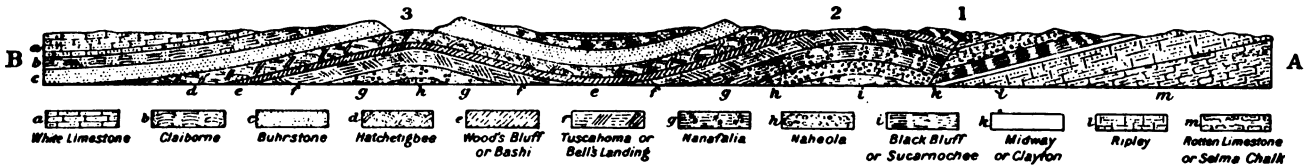
*First Bien. Rep. Geol. Ala., p. 150, 1850.

above named, leads one to suspect the existence of several other folds, notably one involving the black clays of the Black Bluff or Sucarnochee group along the Tombigbee River, another concerning the *Gryphæa thirsæ* beds in the central part of Marengo county and in the Grampian Hills region of Wilcox county.

We have determined approximately the limits of the Hatchetigbee anticlinal and of the Lower Peach Tree fold and its associated fault in the immediate vicinity of the Alabama River. We have also followed a line of uplift from near Jackson down to the Lower Salt Works in Clarke county.

The accompanying Plate XI, and an inspection of the map, will show the geographical position and the relations of these two anticlines and the Bethel fault.

GEOLOGICAL SURVEY OF ALABAMA. COASTAL PLAIN REPORT. PLATE XI.



SECTION ALONG THE LINE A.B. IN WILCOX, CLARKE, AND WASHINGTON COUNTIES.

Through the Bethel fault (1) Lower Peach Tree Anticlinal (2) and the Hatchetigbee Anticlinal (3)

[In what follows we give some details of the observations on which our knowledge of these undulations is based and we also append a few notes concerning the irregularities in the surface distribution of the Buhrstone and the underlying beds of the Lignitic in Monroe and Conecuh counties.]

(1) The Lower Peach Tree Anticline.

In ascending the Alabama River we find the Wood's Bluff marl at the water level at Johnson's wood yard, a few miles below Bell's Landing. At the latter locality a marl bed, which is about 115 to 120 feet below the Wood's Bluff marl, and which we have called the Bell's Landing marl, is some 25 or 30 feet above water level. Nine miles farther up the river, at Lower Peach Tree, this bed is 100 feet above water level, while at Yellow Bluff, several miles still farther up the river, it is seen within 10 feet of water level, and the Wood's Bluff marl appears about 115 or 120 feet above it on the hillside immediately back of the river bluff.

Above Yellow Bluff the river makes a bend towards the southeast, so that the Wood's Bluff marl is not seen again along its banks in this direction; at Bethel, however, a few miles west of Yellow Bluff, we see the Wood's Bluff marl and the *Gryphæa thirsæ* beds, which are separated by at least 250 and probably by over 300 feet of strata, coming to the surface within half a mile of one another and not more than 120 feet hypsometrically apart. This disposition of things appears to show that just north of Bethel there is either a very abrupt change in the angle dip of the strata or a stratigraphic break. I have examined the ground very carefully on several occasions, and have failed to see any evidence of high angle of dip, but, on the contrary, have obtained the clearest evidence of the existence of a fault of nearly 200 feet vertical displacement, traced from Bethel across the river to Black's Bluff, and it probably extends much farther in each direction from these limits. We shall call this the Bethel fault and give below some details of its occurrence.

The Lower Peach Tree fold.—The geographic limits of the Lower Peach Tree fold, so far as we have determined them, have been fixed by the following data: Across Choctaw county, at Wood's Bluff, on the Tombigbee, and at

Cade's Bend, a mile or two above, it appears at the water level, showing a nearly horizontal position. This may be the beginning of the fold, which, beyond Choctaw Corner, eastward, broadens out till at the Alabama River it spreads over an expanse, north and south, of 10 miles or more. In the vicinity of the river, however, its occupation of the surface is not continuous, but the underlying beds of the Bell's Landing series come in and make the intervening country between its two exposures, the one south of Lower Peach Tree, the other in the vicinity of Bethel and Yellow Bluff. In its longer dimension, therefore, this fold appears to rise about the Tombigbee River near Wood's Bluff and to extend with constantly increasing elevation to the Alabama River, Lower Peach Tree occupying the summit of the roll, which has its widest cross section along the Alabama River. Eastward from this river, I have followed, with the exception noted below, a single outcrop only of the Wood's Bluff marl across Monroe county along the course of Flat Creek, and this is the continuation of the lower of the two outcrops of the bed above spoken of, as exhibited in Wilcox county west of the river and south of Lower Peach Tree, while, of the northern or Bethel outcrop, I have seen only one occurrence east of the river, viz., near Black's Bluff. This is no doubt in great measure due to the fact that there is on the eastern side of the river, opposite Yellow Bluff, a good deal of low country from which the older strata have been removed by denudation.

The fold involves, so far as concerns their surface outcrop, the Bell's Landing, the Wood's Bluff, and the Hatchetigbee series of the Lignitic, for the clays of the latter series are to be seen overlying the Wood's Bluff marl in the hills west of Yellow Bluff. I have not seen any evidence either of the broadening or of the duplication, by reason of this fold, of the outcrops of the Buhrstone rocks which immediately overlie the Hatchetigbee beds.

To summarize, we can trace this anticline in the direction of its axis from Wood's Bluff, on the Tombigbee River, across Clarke county, to the Alabama River, where it has its greatest elevation and its broadest cross section; beyond the river, eastward, we have traced it as far as Black's Bluff. The northern limit of this fold, in the vicinity of Bethel is a fault of at least 200 feet displacement, length not ascertained, already mentioned above.

The Bethel fault.—To obtain a clear idea of this fault it is necessary to recall the stratigraphic relations of the several subdivisions of the Lignitic which it involves. The Wood's Bluff marl, with indurated limestone bowlders and its characteristic fossils, is our best landmark. Above this marl lie the sandy clays of the Hatchetigbee section, 175 feet in thickness. These latter beds are only slightly concerned in the fault. Below the Wood's Bluff marl we have about 120 feet of sandy clays and clayey sands, the upper 75 feet of which hold several beds of lignite, and then another marl bed, the Bell's Landing marl. Below this marl we have at Lower Peach Tree about 100 feet of gray sandy clays containing two marl beds (Gregg's Landing marl being the upper of the two.) In these sections, therefore, we have over 400 feet of strata, the exact relations of which are clearly seen at Yellow Bluff and at Lower Peach Tree.

The Nanafalia section consists at top of 50 feet or more of gray, sandy clays; showing a great tendency east of the Alabama River to indurate into hard rocks, resembling the Buhrstone, to which, for convenience, I give the name *pseudo-Buhrstone.* Below the pseudo-Buhrstone are at least 80 feet of sandy strata, characterized by the presence of *Gryphæa thirsæ*, and below these still, about 70 feet of cross bedded, glauconitic sands, with a few obscure fossils in the upper part, and a bed of lignite, from four to seven feet in thickness, near the base. As we have already intimated

several times, we have seen no exposures which exhibit both the Lower Peach Tree beds and the pseudo-Buhrstone, so that it has been thus far impossible to determine the dimensions of the gap between the base of the Bell's Landing (at Lower Peach Tree) and the summit of the Nanafalia section (at Gullette's Landing); and the Bethel fault, coming as it does exactly at this place in our geological scale, serves to complicate matters still more. In estimating the vertical displacement caused by the fault, there is always the unknown quantity embraced in this gap to be considered, and our estimates are to be taken as exclusive of this unknown quantity.

Following are given some details concerning the fault. At Bethel, S. W. $\frac{1}{4}$ of Sec. 35, T. 12 N., R. 5 E., the Wood's Bluff marl occupies the summit of the hills, and about half a mile south we find the *Gryphœa thirsœ* beds. The Wood's Bluff marl may also be seen on most of the hills between Bethel and Yellow Bluff and at the latter place, and a line drawn from Bethel to Yellow Bluff will just about define the limit of the marl towards the east. As we descend towards the east from any of these hills, capped with the Wood's Bluff marl, we come directly, and usually within 50 feet vertical distance, upon the pseudo-Buhrstone, and 60 or 70 feet below that upon greensands holding *Gryphœa thirsœ*. Near Bethel towards the southeast then the fault brings together, or rather within 50 feet of each other, the Wood's Bluff marl and the pseudo-Buhrstone, a displacement (taking no account of the gap between the Bell's Landing and Nanafalia sections) of more than 150 feet. At Yellow Bluff, as we have seen in foregoing pages, there are exposed all the strata from the Wood's Bluff down to the Bell's Landing marl. Up the river, within half a mile of the landing, this marl dips below the water level. Less than half a mile further up the river, beds of *Gryphœa thirsœ* appear in the left bank. Here some of the beds overlying the Bell's Land-

ing marl are brought together with *Gryphœa thirsœ* beds, a displacement, as before, of 175 feet or more. Again, across the river, on the plantation of Mr. James Tait, Sec. 24, T. 11 N., R. 6 E., near Black's Bluff, we find the Wood's Bluff marl forming the second bluff, about 100 yards from the river, while the lower beds of *Gryphœa thirsœ* marl, Nos. 10, 11 and 12 of the Gullette's Bluff section, make the immediate bank of the river. In this case the strata between Wood's Bluff and Bell's Landing marls (120 feet), those below the Bell's Landing marl at Lower Peach Tree (100 feet), the pseudo-Buhrstone (50 feet or more), and about 30 or 40 feet of the *Gryphœa thirsœ* beds have been engulfed, a displacement of not less than 300 feet, leaving out of account, as before, the gap mentioned. We have traced the fault from Bethel to Black's Bluff, a distance of 10 miles or more. Eastward from Black's Bluff, near where the Camden road crosses Gravel Creek, on Yankee Branch, a thick bed of lignite (4 feet or more) occurs immediately and to all appearances conformably below beds of *Gryphœa thirsœ*. The Coal Bluff lignite has above it some 60 feet or more of glauconitic sands, separating it from the *Gryphœa thirsœ* beds, so that this contact of two elsewhere widely separated beds (if this be the Coal Bluff lignite) could only be brought about by some kind of displacement. And lastly, at Black's Bluff, we have a thick bed of lignite in contact with the *Gryphœa thirsœ* beds. From its close proximity to the Wood's Bluff marl (at the line of fault above described), one would be inclined to consider this as one of the lignites of the Wood's Bluff series but for its thickness. The certain identification of these lignites and their relations to the Bethel fault we have still to work out.

(2) The Hatchetigbee Anticline.

The axis of this fold, like that of the preceding, has a northwest-southeast direction. At the southeastern end and

also at the northwestern it sinks gradually to the level of the undisturbed beds. It may be traced from near Nicholson's Store, in Choctaw county, across that county, through Bladen Springs, into the northeastern corner of Washington county at Hatchetigbee Bluff, and thence across the river for about ten or twelve miles into Clarke county. It is about twelve miles across in its widest part, i. e., from Coffeeville southwestward. It involves, so far as concerns their surface exposure, the following strata: The White Limestone, the Claiborne, the Buhrstone, and the Hatchetigbee beds, aggregating, with the exclusion of the White Limestone, about 500 feet of strata. It appears to have exerted no influence upon the direction of the drainage.

In the following routes we obtain the data from which we have outlined this fold:

First. From Jackson to Coffeeville and thence northward to Wood's Bluff. On this road, 6 miles north of Jackson, the first well defined outcrop of Tertiary rocks is encountered. These rocks belong to the Buhrstone, but before reaching them the presence of the Claiborne beds at no great depth below the surface is very clearly revealed in the frequent occurrence of patches of the characteristic red, limy clays produced by the action of these beds upon the red loam. Beyond this the sands and clays of the underlying Hatchetigbee group are seen along the slope leading down to the crossing of Jackson's Creek. By turning eastward from this place the Claiborne sands, with their characteristic fossils, can be seen on Stave Creek, in sections 8 and 9 of T. 7 N., R. 2 E. This I take to be the southeastern limit of the anticline, for looking eastward and southeastward from this place we see nothing but the characteristic landscape of the Lime Hills region. Proceeding northward, the Buhrstone rocks are again encountered about eight miles from Coffeeville, and they extend thence to within five miles of that place. The limit of the anticline in another place,

southeast of Coffeeville, is ascertained by going northeastward from Salitpa post-office, which is on the Hatchetigbee formation in S. 31, T. 8 N., R. 1 E., towards Dead Level, in Clarke county. In this direction the Buhrstone is crossed between three and five miles from Salitpa post-office. Coffeeville itself is upon the Claiborne, and going northward we pass first into the White Limestone, and at Turkey Creek, near the northern limit of T. 10 N., R. 2 W., into the Buhrstone, the Claiborne as usual making very little show upon the surface, except in the red, limy clays above noticed. The Buhrstone ridge just alluded to becomes very prominent at White Bluff, and from that place an uninterrupted view may be had of all the underlying strata down to the Wood's Bluff group. In this route, therefore, we pass over the anticline between Jackson and Coffeeville and over a syncline, with White Limestone as the uppermost formation, between Coffeeville and White Bluff, while by diverging eastward in two or three places the eastern limits of the anticline can be pretty accurately determined.

Second. On the western side of the river the anticline is equally well marked along the route from Saint Stephens, through Bladen Springs, to Butler, in Choctaw county. On this road the White Limestone may be seen to within nine miles south of Bladen Springs; then occurs a strip of pine lands, in which the underlying Claiborne formation is not often clearly seen. At one place, however, near the road in the northeast corner of section 29 (corresponding to section 27 in the ordinary township)* T. 8 N., R. 2 W., about a quarter of a mile west of the Tony Rail place, in the bluff over a spring, about six feet of the Claiborne sands are exposed. The upper part of this exposure is a mass of shells packed in a yellowish red sand, as at Claiborne; the lower part at the water level is a hard greensand filled with shells,

*In this township the sections are not numbered in the usual manner.

as at Pugh's Branch, in Clarke county. *Crassatella protexta* is here the commonest shell; but *Melongena alveata*, *Monoceros armigerus*, *Ancillaria subglobosa*, *A. scamba*, *A. staminea*, and other Claiborne forms are also abundant. This locality is about a quarter of a mile north of the last Lime Hill. Beyond this, towards Bladen Springs, the Buhrstone rocks are first seen at the bridge across Sinta Bogue in the northwest corner of S. 14, T. 8 N., R. 2 W., six miles from the springs, and they continue up to within two miles. About the central part of this outcrop, four miles from the springs, there is a marl bed several feet in thickness, containing great numbers of a shell closely allied to *Ostrea sellæformis*. This marl is found just below a hard ledge of claystone, and in the fields near by lie many fragments of rock filled with silicified Claiborne shells. The springs are upon the upper Hatchetigbee beds, for going northwards the Buhrstone is again met in the hills about two miles north of the springs, and outcrops along this road for about four miles. Beyond this Buhrstone belt we come upon the Claiborne sands on the hill just south of Souilpa Creek, and going down the hill we see the *Ostrea sellæformis* beds, and in the immediate bank of the creek the bed of comminuted shells in a matrix of greensand, precisely like that in the lower part of the Claiborne bluff and at Coffeeville landing. At Barryton Mill, about the northeast quarter of S. 13, T. 10 N., R. 3 W., about a mile east of the road we are now describing, this bed of comminuted shells, with numbers of large and perfect shells of *Ostrea sellæformis*, forms the bed and banks of the creek. To the westward also of this road the banks and channel of Oaktuppah Creek are formed of the lower Claiborne beds, which outcrop again on the hills some four miles north of the creek. The belt of Claiborne beds is crossed on this road from the southern banks of Souilpa Creek northward about seven or eight miles. This great width of outcrop is due to the fact that the beds

form a shallow synclinal basin. This basin holds a narrow belt of White Limestone, which may be traced from Womack Hill, S. E. ¼ S. 4, T. 10 N., R. 2 W., northwestward to the Mississippi line at Nicholson's Store. The outcrop of White Limestone at Womack Hill is about two miles long and one hundred or two hundred yards wide. Then northwestward in Mrs. Nix's field, S. 2, T. 10 N., R. 3, W., is another outcrop, about a mile long and two hundred yards wide. Still farther northwestward the White Limestone is next seen on the south side of Oaktuppah Creek, on Dr. Gilbert's old place and between that place and Mr. Troup Trice's. Then on the north side of Oaktuppah Creek, on Messrs. Seaborn Bonner's and Rigby's lands, Secs. 22, 23, 26 and 27, T. 10 N., R. 4 W., is a narrow tract, about two miles in width north and south; again, still farther westward, on Mr. James Bonner's land, N. W. ¼ of Sec. 15, T. 11 N., R. 4 W., is about a square mile of the White Limestone prairie. Beyond this the prairie belt widens out and merges into the great mass of prairies west of the end of the Hatchetigbee anticline. Returning to our Bladen Springs and Butler road, after crossing the syncline of Claiborne beds which holds the narrow belt of White Limestone, we come upon the Buhrstone rocks again some ten miles south of Butler, and these make the country to within five miles of that place, where they are succeeded by the Hatchetigbee beds, and at Butler by the Wood's Bluff beds.

Third. Along another route, approximately parallel to the two preceding, but in the western part of Choctaw county, we discover that our anticline has sunk beneath the surface, though still impressing itself upon the country by keeping the White Limestone as the surface rock over a distance north and south of more than twenty miles. A very similar state of things may be seen beyond the southeastern end of this fold in Clarke county, as below noted. The following details will serve to make this clear: Three

miles south of Pushmataha the Wood's Bluff marl is seen on Rabbit Creek, and a mile or two further south the first of the Buhrstone, which rock then makes the country southwestward as far as the S. E. $\frac{1}{4}$ of Sec. 25, T. 12 N., R. 5 W., near Mr. Johnson Allen's. In this vicinity *Ostrea sellæformis* beds are found upon many of the high hills which show Buhrstone rocks at their bases. The line between the two formations may therefore be drawn here. Going still southward we find the *Ostrea sellæformis* or Claiborne beds at lower and lower levels, till on Billy's Creek, in Sec. 7, T. 11 N., R. 4 W., they are at the water level, and we get a first rate section extending nearly up to the White Limestone.

Section on Billy's Creek, Choctaw County.

1. Red, white and yellow, laminated sands, with yellow clay partings..... 15 feet.
2. Laminated, gray clays, with bits of leaves and indistinct leaf impressions.....12 to 15 feet.
3. Greenish yellow, calcareous, glauconitic sands; no fossils, 8 feet.
4. White, calcareous sands, with *Ostrea sellæformis*.....6 feet.
5. Hard, white ledge, with shell casts.....1 foot.
6. White, calcareous sands, with *Ostrea sellæformis*, passing below into coarse, yellow sands, and then to gray, calcareous sands, holding a few friable shells; hard ledges traverse these beds near the top; in all.....12 feet.
7. Highly fossiliferous, gray, calcareous sands, holding *Ostrea sellæformis* (small shells), *Osteodes Wailesii*, *Turbinolia Maclurei*, *Nucula magnifica*, *Pecten Lyelli*, &c. These are alternating streaks of barren sands and fossiliferous sands.....20 feet.
8. Gray, laminated clays to base of bluff.....10 feet.

One of the beds of No. 7 is densely packed with the small form of *Ostrea sellæformis* (*divaricata*), and this is the bed which crops out so frequently upon the hills to the northward of this locality. A comparison of the elevations of this bed in different places shows that it dips about 50 feet to the mile. South of Billy's Creek we enter upon the wide belt of prairie land (White Limestone) which extends to

the northwestern corner of Washington county four or five miles below Isney. The line between Ranges 4 and 5 W. marks about the western limit of the Hatchetigbee anticline, for east of Push Cush Creek, about Sec. 17 or Sec. 18, T. 10 N., R. 4 W,, the outcrops of the *Ostrea selliformis* beds are seen.

The map will show that in the western part of Washington and Choctaw counties and in adjoining parts of Mississippi the width (north and south) of the White Limestone belt is much greater than elsewhere, except in the eastern part of Clarke county. This is undoubtedly in great measure due to the influence of our Hatchetigbee fold; but there is also a very considerable increase in the thickness of the beds constituting the lower or Jackson division of the White Limestone in the Western part of Alabama and in Mississippi, or perhaps it would be more correct to say that there is a very considerable increase in the thickness of the beds of gypseous clay of the formation in these localities. The "prairie" character of the soils of this formation is much more pronounced in Western Alabama and in Mississippi than elsewhere eastward.

Fourth. The limits of the anticline are also well defined along several roads leading out from Bladen Springs.

(*a*) On the road from Bladen Springs to Milry, in Washington county, the Buhrstone and Claiborne formations are crossed, and at a distance of seven or eight miles from the springs appears the first outcrop of White Limestone.

(*b*) On the lower road from the springs to Isney the first outcrop of Buhrstone is about one and a half miles and the last about five miles from the springs. A very conspicuous bed in these Buhrstone rocks is a greensand, several feet in thickness, of very bright, light green color, to be seen on almost every hillside from three to four and a half miles from the springs. In many places the upper part of this

bed has been oxidized to deep red sand. From the five mile post west of the springs out to the lower line of Sec. 15, T. 9 N., R. 4 W., we cross diagonally the outcrop of the Claiborne beds, coming into White Limestone at the last named locality, where along a hillside Claiborne beds are seen, with White Limestone overlying them. Thence out to Isney (and beyond to Mississippi) the country is made by the White Limestone. A very good section of the Upper Claiborne beds was obtained in Sec. 13, T. 9 N., R. 4 W.

Section near Jordan's Mill.

1. Yellowish, clayey sands, with some Claiborne fossils in a soft, friable condition; lower part of this bed bluish.....25–30 feet.
2. Projecting ledge of coarse grained greensand, with a large number of badly preserved Claiborne fossils.....4 feet.
3. Coarse grained greensand, with Claiborne fossils, compact and hard.....10 feet.

The upper half of No. 3 is coarser in grain and more fossiliferous than the lower, but the latter contains a number of smaller forms. A little northwest of this, in Sec. 2, T. 9 N., R. 4 W., at Shoemaker's Mill, this greensand bed is again seen, holding *Crassatella alta.* While in some respects these two outcrops resemble the Claiborne sands (main fossiliferous bed at Claiborne), there are differences observed which lead us to think that their position is below these sands. The limit between Claiborne and White Limestone is seen again about half a mile northeast of Fail's Store.

(*c*) Along the upper road from Isney to Bladen Springs the Buhrstone belt is entered at Powe's Store, about two miles northeast of Silas post office, and from this point on by the Turkey Creek bridge (about Sec. 10, T. 9 N., R. 2 W.) we cross only Buhrstone rocks. No Hatchetigbee beds are observed. From this circumstance it would seem that the outcrop of the last named beds, passing through Bladen Springs, does not extend northwest beyond the line running from Silas to Turkey Creek bridge, the two points being on

opposite slopes of the anticline. In the piny woods northeast of Isney there are many outcrops of the *Ostrea sellæformis* beds, betrayed by the appearance of red, limy clay spots in the woods. Thus at Singeley & Peel's store, Sec. 11, T. 10 N., R. 5 W., the immediate surface is sandy and timbered with long leaf pine, but prairie spots (White Limestone) occur on the hillsides in all directions, Two and a half miles due east of this store, in the banks of Push Cush Creek, the *Ostrea sellæformis* beds are seen, as also at Marion Carroll's (Sec. 21, T. 10 N., R. 4 W.), and in the piny woods southeastward, eastward, and northeastward, for a good many miles.

(*d*) Again, going towards Bladen Landing, Sec. 3, T. 9 N., R. 2, W., the road is over Buhrstone all the way, after leaving the immediate vicinity of the springs.

(*e*) And lastly, going from the springs to Coffeeville, after leaving the Hatchetigbee clays of the springs, the road passes over Buhrstone to the river lowlands; it then follows the river for three miles (no rocks seen) to Coffeevile, where the Claiborne rocks are well exposed. At Coffeeville Landing these rocks have a very strong dip towards the east or northeast, and the White Limestone is encountered within a very short distance of the river bluff eastward. Thus, on the road from Coffeeville to Grove Hill, we see orbitoidal limestone at the level of the small water courses, within five miles of the former place, and at six miles from Coffeeville this rock forms the banks of Satilpa Creek. This marks about the lowest part of the depression, for a mile further eastward limy clays containing ribs of Zeuglodon are noticed upon a hillside, at some considerable elevation above the level of Satilpa Creek. These lime hills continue thence to within a mile of Grove Hill, where the Tertiary rocks are concealed by the Lafayette beds.

From these details it will be seen that this anticline has been tolerably well defined on all sides by our observations,

and its representation on the map may be taken as fairly correct. In describing the limits of this undulation we have made use of the Buhrstone rocks more than of other formations, for the reason that the Buhrstone, being in general hard and resistant to denudation, may almost always be seen along the line of outcrop. The Claiborne beds (sands and clays), on the other hand, as a rule, are likely to escape detection. It may, however, be of interest to give the following localities of the occurrences of the Claiborne along the two sides of the anticline.

The ferruginous sand bed, with the great mass of the Claiborne shells, we have seen less frequently than the lower or *Ostrea sellæformis* beds.

The former has been observed on the southern side of the anticlinal on Stave Creek, in the SW. ¼ of Sec. 8 and in the SE. ¼ of Sec. 9, T. 7 N., R. 2 E., in Clarke county; on the Tombigbee river, half a mile above St. Stephens Bluff; also in Sec. 5, T. 8 N., R. 2 W., and in Sec. 29, T. 8 N., in Washington county. Then in Sec. 13, T. 9 N., R. 4 W., and in Sec. 2, T. 9 N., R. 4 W. On the northern side of the anticline the ferruginous sand bed has not come under observation except on the southern bank of Souilpa Creek, about Sec 13 or 25, T. 10 N., R. 3 W.

On the other hand, the lower or *Ostrea sellæformis* beds are to be seen along the whole outline of the anticlinal, and even where the beds do not come to actual outcrop their presence is just as certainly revealed by the occurrence of what are called "piny woods prairies"—that is, red, limy, clay spots in the piny woods. A great proportion of the country underlaid by the *Ostrea sellæformis* beds has a light, sandy soil and is timbered with long leaf pine, and the reaction of the calcareous sands upon the red loams, which occur in these sandy lands, produces the so-called prairie spots. I give a few of the localities of *Ostrea sellæformis* beds around the anticline, beginning at Coffeeville

Landing, where there is a fine exposure. Thence northwestward they may be followed up Oaktuppah Creek, on both sides, and forming the bed of the creek in many places, out toward Nicholson's store. Thus, on both sides of Womack Hill, at Barryton Mill; on Surveyor's Creek, Sec. 36, T. 11 N., R. 3 W.; in the banks of Souilpa Creek, at the bridge, about Sec. 13 or Sec. 25, T. 10 N., R. 3 W.; two miles west of Barryton; in the bed of Oaktuppah Creek, about Sec. 28, T. 11 N., R. 3 W.; in Sec. 20, T. 11 N., R. 3 W.. on Bogue Loosa; in many places northward as far as Lusk post-office, S. W. corner of Sec. 9, T. 11 N., R. 3 W.; in Sec. 25, T. 12 N., R. 5 W.; Secs. 6 and 7, T. 11 N., R. 4 W.; in Sec. 15, T. 11 N., R. 4 W.; many places near center and northern part of T. 10 N., R. 4 W.; and thence along the southern border of the anticline, i. e., about Sec. 7 or Sec. 8, T. 8 N., R. 2 W.; then across the river a few miles north of Jackson, &c. Indeed, with a little practice, the *Ostrea sellæformis* beds are about as easily followed as the Buhrstone. In Clarke county, also, as across the river in Choctaw county, in the syncline lying to the northeast of the Hatchetigbee anticlinal, the Claiborne ferruginous sands are in many places not far below the general level of the country, and are exposed in the beds of the water courses. Examples of this are seen in the central part of Sec. 23, T. 9 N., R. 2 E., and in the S. E. $\frac{1}{4}$ of Sec. 18, T. 9 N., R. 3 E.

It will be noticed that along the sides of this anticline, as well as where the Buhrstone first dips below the surface in the northern part of Clarke and Choctaw counties, the rate of dip is much greater than the average of 30 feet to the mile; for the thickness of the Buhrstone is about three hundred feet, and its outcrop, with a dip of the strata of thirty feet to the mile, would be about ten miles broad, but in the instances cited above this outcrop will not average more than four miles in width. A part of this difference is undoubtedly due to the fact that the Buhrstone usually forms high

hills, with a rather steep encarpment looking northward, but a part is also certainly due to the more rapid dip along these lines.

(3) Other Buhrstone Displacements.

A few words respecting the appearance of the Buhrstone rocks at localities further south than the anticline just described may not be out of place here. A few miles south of Jackson, on the road to Gainestown, there is a hill which rises to a height of 300 feet above the adjacent water courses. Upon its summit there is a good outcrop of Buhrstone rocks, and in immediate contiguity with it Orbitoidal White Limestone, at the same level. This state of things may be seen also southward and northward of the locality named for at least a mile in each direction, and southward presumably as far as the Lower Salt Works (see below). The locality mentioned is about the corner of the four sections, 14, 15, 22, 23, T. 6 N,, R. 2 E.; and a mile north of it, in the Etheridge Old Fields, there is another occurrence of Buhrstone and White Limestone in actual contact apparently at the same level, for in both these cases, as we go eastward, we find the White Limestone making the country for many miles. In the same range of hills with the outcrops above mentioned (but eastward of the Buhrstone occurrences), there are places where the ravines have cut down into the *Ostrea sellæformis* beds of the Claiborne. The Tertiary strata lying westward of these localities have generally been removed by denudation, but in one place at least we find Orbitoidal White Limestone lying to the *west* of the line of contact of Buhrstone and White Limestone, so that to all appearances we have here a narrow belt of Buhrstone (north and south) coming up right in the midst of the White Limestone, and with the latter in visible contact with it on its eastern side. When we go a few miles farther south, to what is called the Central Salt Works, in the northern part

of Sec. 34 or the southern part of Sec. 27, T. 6 N., R. 2 E., we find the Orbitoidal White Limestone at the level of the water courses, but a mile east of the Salt Works, up Salt Creek, on ascending a hill we pass over what appear to be the Hatchetigbee strata. Of this I could not be perfectly sure, as no well defined fossils were obtained; but on another branch of the creek, which flows from the north, heading nearly in the localities first mentioned, we find the Buhrstone making the lowermost forty or fifty feet of the hills on both sides of the branch, while the upper strata of the hills were White Limestone, apparently *conformably overlying the Buhrstone*, the strata of the latter at one place, where they were clearly shown in a low bluff, being approximately horizontal. This locality is near the upper edge of Sec. 35 or of Sec. 36 in T. 6 N., R. 2 E., or in the lower part of the section lying next towards the north. At Mr. F. Payne's spring, on the N. W. $\frac{1}{4}$ of N. E. $\frac{1}{4}$ of Sec. 11, T. 5 N., R. 2 E., the Buhrstone is found, while directly west, on the bank of the river, in Secs. 16, 17, 21, 28, and 29 the White Limestone appears. So, also, east of Mr. Payne's house there are lime sinks and outcrops of White Limestone in Secs. 12, 13, 24, &c. Though not actually seen, it would appear that here, also, we have the White Limestone lying directly upon the Buhrstone, the strata falling away rapidly westward so as to bring the former rock down to the river within two or three miles towards the west. A few miles below this, in Secs. 21 and 28, T. 5 N., R. 2 E., at the Lower Salt Works, we have the section already given, in which the White Limestone and the Buhrstone are shown in direct contact, the former apparently directly and conformably overlying the latter, just as appears to be the case at Mr. Payne's, at the Cantral Salt Works, and probably also at the first locality mentioned above (Secs. 14 and 15, T. 6 N., R. 2 E.).

I should be inclined to explain these anomalies on the supposition that a north and south fault has brought the

Buhrstone and the White Limestone together, but for the fact that at most of the localities above mentioned the White Limestone may be seen directly, and to all appearance conformably, resting on the Buhrstone. Whether by a fault or otherwise, all the Claiborne strata are wanting at all these localities, and my observations show also either that there is an anticlinal axis extending from Sec. 28 in T. 5 N., R 2 E., a little east of north up to Sec. 14, T. 6 N., R. 2 E., which brings the Buhrstone above drainage along this line and for this distance, or that this elevation has been brought about by a fault. There are great difficulties in the way of making satisfactory observations in this part of the State, as thick beds of pebbles and loam (in some places, as at Mr. Payne's, 75 feet thick) cover the whole face of the country, except where they have been removed by the few streams; but I hope to have this fold or fault fully traced out in another season.

The sulphur springs at Jackson comes apparently through the Buhrstone out of the Hatchetigbee strata, as is the case at Bladen Springs, Tallahatta Springs, the Upper Salt Works, the Lower Salt Works, &c. The Jackson well, however, is in the low grounds of Bassett's Creek, and no Tertiary rocks show in the immediate vicinity, but the Buhrstone and the Hatchetigbee sands appear on a hill at no great distance towards the east.

As before stated, the White Limestone is the country rock through which all the lower part of Clarke county, as far south at least as Choctaw Bluff and the Lower Salt Works; but away from the streams these Tertiary beds are hidden by Lafayette sands, and their presence is revealed only by numerous lime sinks which are of such frequent occurrence in the piny woods of this section. Below the Lower Salt Works the Eocene rocks may be continuously followed down to Oven Bluff, a few miles distant, southward of which point they do not appear to come again to the surface. It is prob-

able, however, from the occurrence of lime sinks, that the White Limestone underlies the surface at no great depth for many miles further in this direction.

The uplift of the Lower Salt Works is felt across to the Alabama River, but not to the same degree as here, for at Gainestown and at Choctaw Bluff the lower measures of the White Limestone are at the water level.

It would not be correct to say that these undulations are not felt at all across the whole of Clarke county; for, although the underlying Claiborne and Buhrstone rocks are not, so far as we now know, lifted much above the general drainage level in the eastern part of the county after having once disappeared beneath the surface, the undulations have still been operative in keeping the White Limestone as the surface rock over an extent, north and south, of 30 miles. This is well illustrated along the meridian of Grove Hill, Clarke county, where we find the White Limestone as surface rock from about five miles north of that town down to Choctaw Bluff, and the thickness of the formation is not much over 300 feet. Moreover, at several localities we find the underlying Claiborne beds at no great depth below the general level of the country. Now, if we travel southward of this last outcrop of the White Limestone at Choctaw Bluff, through Monroe and Escambia counties, and eastward also, in Covington, Coffee, and Geneva counties, we find the country generally level piny woods, with a surface mantle of Lafayette, in which, however, the frequent occurrence of depressions caused by lime sinks reveals the fact that the White Limestone is at no great distance from the surface at any place.

In the southeastern part of the state these undulations become still more pronounced and general. Thus along the Chattahoochee river we find the uppermost of the Claiborne strata passing below the water level about the mouth of

Omussee creek; yet at Geneva and in all that vicinity, the same rock appears in the banks of the Pea river *above* low water mark, fifteen or twenty miles further south than the point above named. The occurrence of red lime lands in Florida north of Marianna leads us to infer that this slight dip, approaching to horizontality of the strata, continues on into Florida also, for as a rule the red lime lands are derived from the very lowest of the St. Stephens series immediately overlying the Claiborne.

And, still further, if we pass into Florida we find this rock again at the surface over the greater part of the peninsula, although, as recent discoveries of Mr. L. C. Johnson and others have shown, covered in many places by later deposits of Miocene age, and in lower Florida, of Pliocene age.

The elevation of the Florida peninsula was therefore, in part at least, subsequent to the deposition of the Pliocene beds, and the undulations of the Alabama Tertiary may date back to the same epoch. That these disturbances antedate the elevation of the Terrace epoch is shown by the circumstance that the Lafayette deposits rest upon an eroded surface of the Tertiary (Eocene and Miocene) rocks.

Summary of the Leading Features of Tertiary Strata of Alabama (Plate XXVIII).

With a brief review of the distinguishing characteristics of the divisions of the Tertiary above made, we conclude this part of our subject.

The whole thickness of the strata of the Tertiary group of Alabama occurring in the vicinity of the two rivers is between 1,620 and 1,700 feet. This estimate is based upon actual measurement, except at one or two horizons, and even in these places we are able to give a close estimate of the thickness of the strata not measured.

We have adopted the following fourfold division of the Tertiary:

(1.) The St. Stephens or White Limestone.
(2.) The Claiborne.
(3.) The Lignitic.
(4.) The Clayton or Midway.

In all that follows the strata are described in descending order.

1. The White Limestone.

This subdivision is calcareous throughout, but the lowermost 60 feet are more argillaceous than the rest. The minimum thickness is 350 feet, of which the uppermost 150 feet consist of a tolerably pure but somewhat silicious limestone, filled with coral masses. The next succeeding 140 feet or more are made up of a soft, white limestone, often quite pure and filled with *Orbitoides Mantelli*. The lowermost 50 feet are of impure, argillaceous limestone, which in disintregrating yields a black, calcareous soil similar to that derived from the Rotten Limestone of the Cretaceous This lower portion of the White Limestone surpasses the others in the variety of its fossil contents.

(2) The Claiborne.

As shown above this is further subdivided into the (A) Claiborne proper, and (B) the Buhrstone, and the aggregate thickness is some 450 feet.

A. Claiborne.—The thickness is 140 to 145 feet, the materials are sands and clays, which are generally calcareous and often glauconitic. Near the top of the subdivision is a bed of glauconitic sand 15 to 17 feet in thickness, filled with shells in a perfect state of preservation. The sandy clays forming the lower 50 feet are likewise filled with a great variety of shells in a good state of preservation. The intervening calcareous clays and calcareous sands are distinguished by the great numbers of shells of *Ostrea sellæformis*

which they hold, as well as by the comparative rarity of other forms.

B. Buhrstone.—The minimum thickness of this formation is 300 feet; the materials are almost altogether aluminous and silicious, consisting of aluminous sandstones, claystones and quartzitic sandstones, with occasional thin beds of glauconitic sand. The few fossils which have been obtained from this division are mostly in the form of casts. They do not appear to differ specifically from those of the overlying division.

(3) The Lignitic.

This is the most massive of the subdivisions of the Tertiary, having a thickness which can hardly be less than 900 feet. It also presents a greater variety in mineral composition, as well as in fossils, than the other divisions. In the most general terms, the Lignitic strata are cross bedded sands, thin bedded or laminated sands, laminated clays and clayey sands, and beds of lignite, as well as the lignitic matter which merely colors the sands and clays. With these are found interbedded, at several horizons, strata containing marine fossils. For the sake of greater convenience and clearness of description we present the Lignitic in seven sections, each of which is characterized by one or more beds of marine fossils included in it. These sections are as follows:

A. The Hatchetigbee section.—This section is 175 feet in thickness, made up of sandy clays of prevailing brown or purplish color, containing three or four beds of marine fossils in the uppermost 75 feet, and of somewhat similar purplish brown, sandy clays nearly devoid of marine fossils in the lower 100 feet. All these brown, sandy clays become much lighter colored upon drying and exposure to the weather.

B. The Wood's Bluff or Bashi section.—This is 80 to

85 feet in thickness. The uppermost 30 feet of the section consist of dark brown clays passing into a greensand, which holds a great variety of finely preserved marine shells. Below this greensand marl are gray, sandy clays, with four or five thin beds of lignite within the first 25 feet, succeeded by about 30 feet of cross bedded sands, with a two foot seam of lignite at the base.

C. The Tuscahoma or Bell's Landing section.—This is 140 feet in thickness, and includes two important marine beds, and a third, quite small and apparently unimportant. These fossiliferous beds are interstratified with yellowish sands in the upper and rather heavy bedded, sandy clays in the lower part of the section. The upper marine bed, called the Bell's Landing marl, is about ten feet in thickness and has 40 feet of sandy strata above it. The middle bed is called the Gregg's Landing marl, and it is twenty to twenty-five feet below the preceding; it is about five feet in thickness. The lowermost of the fossiliferous beds of this section is only about one foot in thickness and lies about fifty feet below the Gregg's Landing bed. It is highly glauconitic, but does not contain any great variety of fossils The Bell's Landing marl is distinguished from all others in Alabama by the great size of the shells which it contains.

D. The Nanafalia and Coal Bluff section.—The strata of this section are 200 feet in thickness and consist of about fifty feet of gray sandy clays at top, which show a tendency to indurate into tolerably firm rocks resembling very closely some of the strata of the Buhrstone. Below this, about eighty feet of sandy beds, often strongly glauconitic, characterized throughout by shells of a small oyster, *Gryphæa thirsæ*. Near the base of this sandy division there is a bed about twenty feet thick, literally packed with these shells. Below the *Gryphæa thirsæ* beds follow some seventy feet of cross bedded sands, glauconitic and apparently devoid of fossils, including, about ten feet from the base of the sec-

tion, a bed of lignite which varies in thickness from four to seven feet.

E. The Naheola and Matthews's Landing section.—It is difficult to give the precise thickness of this section, since it varies on the two rivers. We have placed it at one hundred and thirty to one hundred and fifty feet; the strata are gray, sandy clays in the main, alternating with cross bedded sand. The beds of dark, sandy, and glauconitic clay, containing marine fossils, lie at the base of the section. At Naheola on the Tombigbee the upper and more glauconitic part of the bed is most prominent, while at Mathews's Landing on the Alabama, the lower part of the bed, dark gray sandy clay forms the bluff.

F. The Sucarnochee or Black Bluff section.—Here again we have difficulty in determining the exact thickness, since on the Tombigbee the strata of this section are spread over an extent of surface which would, with uniform dip, correspond to a thickness of over two hundred feet, while on the Alabama, and more particularly inland in the eastern part of Wilcox county, the thickness is not greater than thirty-five or forty feet. Since 80 feet of these beds are seen in superposition at one locality (Black Bluff), we think that the maximum thickness can not be less than one hundred feet. The characteristic strata which compose nearly the whole of this section are black or very dark brown clays, which are in part fossiliferous.

(4) The Clayton.

This includes the Midway and Pine Barren section of former report (Bulletin No. 43). Thickness along the Alabama River 25 feet, increasing eastward up to 200 feet on the Chattahoochee. Along the Tombigbee and Alabama rivers the strata are: a white argillaceous limestone, holding shells or casts of a large nautilus which is characteristic of this horizon (*Enclimatoceras Ulrichi*, White), 10 feet, but in-

creasing to 40 feet in Lowndes and Butler. Below this a crystalline limestone with numerous shells of *turritella*, *venericardia*, *rostellaria*, *ostrea*, &c., 8 to 10 feet. East of Butler county these subdivisions have not been recognized but the whole formation becomes calcareous, some parts of the strata resembling very strongly the St. Stephens limestone, other portions being hard and crystalline, underlying country with characteristic red soils and notable for caves, big springs and lime sinks.

PALEONTOLOGY OF THE EOCENE OF ALABAMA.

The following lists are taken from Bulletin No. 1 of the Alabama Geological Survey, by T. H. Aldrich. The species enumerated have been in great part collected by the survey during the years 1550 to 1557, inclusive, though some have been in the collection for many years.

FOSSILS OF THE ST. STEPHENS WHITE LIMESTONE.

Nautilus Alabamensis, Mor.
Cypræa fenestralis, Con.
Scalaria, sp.
Conus mauricensis? Con. cast.
Turritella, sp. Impression.
Pecten perplanus, Mor.
" Poulsoni, Mor.
" anatipes, Mor.
Ostrea Morrisi, Gabb; parida, Mor.
pars.
" cretacea, Mor.
" Georgiana, Con.
" Tuomeyi? Con.
" sp.
Gryphæa vomer, Mor.
Spondylus dumosus, Mor.
Terebratulina lachryma, Mor.
Modiola cretacea, Con.
Crassatella, sp. cast.
Cytherea, sp. cast.
Leda, sp.
Lithodomus, sp. casts.
Pectunculus, sp. cast.
Teredo circula, Aldr.
Venericardia planicosta, Lam.
Orbitoides Mantelli, Mor.
Scutella Rogersi, Mor.
" Lyelli, Con.
" crustuloides, Mor.
Serpula, sp.
Coral, massive.
Echinus infulatus? Mor.
Cidaris, sp.
Sword of Calorhynchus.
Carcharodon augustidens, Ag.
Zeuglodon cetoides.

FOSSILS OF THE LOWER CLAIBORNE, INCLUDING THE BUHRSTONE.

This list does not include all the species observed in the Claiborne bed, (ferruginous sand,) but only the more common forms. The list is, however, tolerably complete as to the species occurring in the strata below the ferruginous sands. A complete list of the Claiborne species would number some four hundred.

Ancillaria altile, Con.
" subglobosa, Con.
" staminea, Con.
" expansa, Aldr.
Agaronia punctulifera, Gabb.
Rostellaria Whitfieldi, Heilpr.
" velata, Con.
Siliquaria vitis, Con.
Monoptygma Leai, Whitf.
Mitra fusoides, Lea.
" dumosa, Con., var.
" Haleanus, Whitf.
" bolaris, Con.
" biconica, Whitf.
Murex engonatus, Con.
Terebra gracilis, Con.
" multiplicata, H. C. Lea.
" divisura, Con., var.
" plicifera? Heilpr.
Marginella incurva, Lea.
Dentalium arciformis? Con.
" thalloides, Con.
" multistriatum, Heilpr.
Hipponyx pygmæus, Lea.
Tuba antiquata, Con.
Odontopolys compsorhytis, Gabb.
Trochita trochiformis, Lam.
Natica limula, Con.
" gibbosa, Lea.
" minor, Lea.
Natica mamma, Lea.
" Newtonensis, M. & A.
" Lisbonensis, Aldr.
" sp.
Sigaretus bilix, Con.
" declivis, Con.
" (Sigaticus) Bœttgeri, M. & A.
Crepidula lirata, Con.
Pseudoliva vetusta, Con.
Turbinella pyruloides, Con.
Conus sauridens, Con.
Voluta petrosa, Con.
" Sayana, Con., var.
Turritella Mortoni, Con.
" humerosa? Con.
" eurynome? Whitf.
" nasuta, Gabb.
" carinata, Lea.
" n. sp.
Mesalia obruta, Con.
" vetusta, Con.
Fusus raphanoides. Con.
" crebrissimus? Lea.
" limulus, Con.
" pagodiformis, Heilpr.
" Mortoniopsis, Gabb.
" irrasus, Con.
" trabeatus, Con. var.
" sp.
Cornulina armigera, Con.
Mazzalina pyrula, Con.
Cadulus abruptus, M. & A.
Buccuinum Mohri, Aldr.
Neptunæa enterogramma, Gabb.
Capulus complectus, Aldr.
" n. sp?
Cylichna galba, Con.
" subradius, Mr.
" Dekayi, Lea.
Bulla Aldrichi, Langdon.
Nassa Calli, Aldr.
" Cancellata, Lea.
Phos Texana, Gabb.
Cerithioderma, n. sp.
Cerithium vinctum, Whitf.
Pleurotoma terebralis, Lam.
" 9 species—not identified.
Cassis Taitii? Con.
Fasciolaria polita, Gabb.
Ringicula biplicata? Lea.
Oliva bombylis, Con.
" Alabamensis, Con.
Pyrula cancellata, Lea.
Actæon elevatus, Lea.
" lineatus, Lea.
" melanellus, Lea.
" pygmæus, Lea.
Solarium scrobiculatum, Con.
" cancellatum, Lea.
" ornatum, Lea.
" elegans, Lea., var.
" sp.
Teinostoma subrotunda, Mr.
Delphinula plana, Lea.
" depressa, Lea.
Planaria nitens, Lea.
Cancellaria alveata, Con.
Buyscon, n. sp.
Scalaria, sp.
Odostomia, 2 sp.
Belosepia ungula, Gabb.
Nantilus, sp.
Lucina compressa, Lea.

Lucina Claibornensis, Con.
" impressa, Lea.
" subtexta, Con.
" papyracea, Lea.
" lunata, Lea.
" carinifera, Con.
Amphidesma linosa, Con.
" tellinula, Con.
Crassatella alta, Con.
" protexta, Con.
" palmula? Con.
Alveinus minutus, Con.
Venericardia, densata, Con.
" rotunda, Lea.
" Sillimani, Lea.
" parva, Lea.
Avicula limula, Con.
Solen Lisbonensis, Aldr.
Cardium Nicolleti, Con., var.
Petunculus stamineus, Con.
Limposis declivis, Con.
" decisus, Con.
" ellipsis, Lea.
" cuneus, Con.
Trigonocælia ledoides, Mr.
Astarte parva, Lea.
" minor, Lea.
" Conradi, Dana.
" sp.
Mactra prætenuis, Con.
" parilis, Con.
" Grayi, Lea.
Corbula oniscus, Con.
" nasuta, Con.
" gibbosa, Lea.
" Murchisonii, Lea. (var. fossata, M & A.)
Pecten Dehayesii, Lea.
" scintillatus, Con.
" calvatus? Mor.
Arca rhomboidella, Lea.
Bysoarca Mississippiensis, Con.
Leda media, Lea.
" multilineata, Lea.
" n. sp.
Nucra alternata, Aldr.
Nucula magnifica, Con.
" ovula, Lea.
" cælata, Con.
" pulcherrima, Lea.
" media, Lea.
" semen, Lea.
" Claibonensis, Con.
" Monroensis, Aldr.
Cytherea Poulsoni, Bon.
" perovata, Con.
" æquorea, Con.
" minima, Lea.
" trigoniata, Lea.
Plicatula filamentosa, Con.
Kelliella Bœttgeri? Mr.
Tellina nitens, Lea.
" ovalis, Lea.
" scandula, Con.
Ostrea Johnsoni, Aldr.
" sellæformis, Con.
" divaricata, Lea.
" sp.
Anomia ephippioides var. Lisbonensis, Aldr.
Egeria rotunda, Lea.
" plana, Lea.
" sp?
Hindsiella, n. sp. (not faba, Mr.)
Grateloupia Moulinsii, Lea.
Pholodomya Claibornensis, Aldr.
Pinna, n. sp. (very large).
Lunulites Duclosii, Lea.
" Bouei, Lea.
Flabellum Wailesii? Con.
Turbinolia Maclurii, Lea.
" pharetra, Lea.
Platytrochus Stokesii, Lea.
Madrepora, 2 sp.
Cyclosmilia?
Serpulorbis, 2 sp?
Scutella Lyelli, Con.
Echinus, sp.
Mylobates.
Otolithus.
Foraminifera, (1 sp).

The following list includes those species of the Claiborne shells that have been identified in the Buhrstone division:

Mitra bolaris Con.
Dentalium arciformis? Con.
Tuba antiquata, Con.
Natica, sp.
Sigaretus bilix, Con.
Turritella carinata, Lea.
Mesalia vetusta, Con.
Cylichna galba, Con.
" subradius, Mr.
Nassa cancellata, Lea.
Pleurotoma sp.
Ringicula biplicata? Lea.
Pyrula cancellata, Lea.
Odostomia, 2 sp.

Nautilus, sp.
Lucina subvexa, Con.
" papyracea, Lea.
Venericardia rotunda, Lea.
" parva, Lea.
Limpopsis ellipsis, Lea.
Corbula gibbosa, Lea.
Pecten Dehayesii, Lea.
Leda, n. sp.
Nucula media, Lea.
Cytherea trigoniata, Lea.
Plicatula filiamentosa, Con.
Teredo, sp?

Mr. T. H. Aldrich has given in Bulletin No. 1 of this Survey tolerably complete lists of the shells collected by the Survey at the different horizons of the Lignitic and these lists I repeat here.

Since the publication of this Bulletin, more complete collections have been made of the shells of the Clayton horizon, and inasmuch as the shells are somewhat peculiar, including a number of new species, Mr. Aldrich has prepared for this report descriptions of these new forms with illustrations. In this we have again to acknowledge the liberality of Mr. Aldrich who has had the illustrations to his paper made without cost to the survey, and it is almost superfluous to say that his article which has undoubtedly taken a good deal of time and study, is also a gratuitous contribution to the survey.

Fossils of the Lignite.

A. Hatchetigbee Group.

Natica limula? Con.
" Mississippiensis? Con. (umblicated var.)
" parva, Lea,
Sigaretus (Sigaticus) Clarkeanus, Aldr., mss.
Nassa cancellata, Lea.
Cerithium, n. sp.
Melanopsis Choctawensis, Aldr.
Voluta petrosa? Con.
V. (Athleta) Tuomeyi, Con.
Pseudoliva vetusta, Con.
Ancillaria subglobosa, Con.
Oliva bombylis, Con.
Cominella Hatchetigbeensis Aldr.
" striata, Aldr.
Cornulina armigera, Con.
Fusus trabeatus, Con.
" pagodiformis, Heilpr.
" subscalarinus, Heilpr.
" subtenuis, Heilpr.
" 3 sp.
Turritella, carinata, Lea.
" sp.
Rostellaria trinodifera, Con.
Pyrula juvenis, Whitf., (multangulata, Heilpr.
Dentalium, sp.
Capulus complectus, Aldr.
Trochita trochiformis, Lam.
Tornatella bella, Con.
Cadulus, sp.
Mitra dumosa, Con., var.
" Hatchetigbeensis, Aldr.
Pleurotoma, 4 sp.
Trophon caudatoides, Aldr.
Triton, n. sp.
Columbella, sp.
Cancellaria alveata, Con.
Solarium elegans, Lea., var.
" granulatum, Lea.
Tuba antiquata, Con.
Scalaria sessilis? Con.
Cytherea Hatchetigbeensis, Aldr.
" Poulsoni? Con.
" Nuttalliopsis, Heilpr.
" sp.
Cardium Nicolleti, Con., var.
" Hatchetigbeensis, Aldr.
Venericardia planicosta, Lam.
" Sillimani, Lea.
" alticosta, Con.
Spondylus dumosus, Mor., var.
Corbula nasuta, Con.
Pectunculus stamineus, Con.
Ostrea Vicksburgensis? Con.

Ostrea cretacea, Mor.
" sellæformis, Con.
Gryphæa vomer, Mor.
Pecten, n. sp.
Leda protexta, Con.
" sp.
Astarte Nicklinsii, Lea.
Arca subprotracta, Heilpr. (protracta Con.
Crassatella producta, Con.
Plicatula filamentosa, Con.
Lucina rotunda, Lea.
" subvexa, Con.
" sp.
Mactra prætenuis, Con.
" n. sp.
Tellina papyria, Con.
Nucula plicata, Lea.
Mysia, sp.
Madrepora, sp.
Cyclosmilia, sp.
Otolithus.

B. Wood's Bluff Group..

Ancillaria subglobosa, Con.
" staminea, Con.
Natica ætites, Con.
" Mississippiensis, Con.
" limula? Con.
" gibbosa, Lea.
" 3 sp.
Sigaretus (Sigaticus) Clarkeanus, Aldr.
Sigaretus bilix, Con.
Turbinella (Caricella) Bandoni, Desh.
Lævibuccinum lineatum, Heilpr.
Rostellaria (Calyptrophorus) trinodifera, Con.
Solarium cupola, Heilpr.
" delphinuloides, Heilpr.
" elegans, Lea., var.
" sp.
Fusus interstriatus, Heilpr.
" subtenuis, Heilpr.
" (Strepsiduria) subscalarinus, Heilpr.
Fusus pagodiformis, Heilpr.
" trabeatus, Con.
" engonatus, Heilpr.
" Meyeri, Aldr.
" Tombigbeensis, Aldr.
" (Strepsidura), sp?
" 5 n. sp.
Pyrula multangulata, Heilpr. (juvenis, Whitf).
Pyrula tricostata, Desh,
Pyropsis perula, Aldr.
? Pleurotoma acuminata, Sowb.
Pleurotoma moniliata, Heilpr.
" (Cochlispira) cristata, Con.
Pleurotoma
" exilloides, Aldr.
" Tombigbeensis, Aldr.
" Tuomeyi, Aldr.
" 11 n. sp.
Dentalium microstria Heilpr.
Cadulus, sp.
Turritella carinata? Lea.
Cassidaria dubia, Aldr.
Voluta (Athleta) Tuomeyi. Con.
" petrosa? Con.
Cancellaria evulsa, Brander (tortiplica? Con.)
Cancellaria sp.
Pseudoliva scalina, Heilpr.
" vetusta, Con.
Ranella (Argobuccinum) Tuomeyi, Aldr.
Trochita trochiformis, Lam.
Phorus reclusus? Con.
Melanopsis Choctawensis, Aldr.
Turbonilla (Chemnitzia) trigemmata, Con.
Trophon gracilis, Aldr.
Cerithium Tombigbeense, Aldr.
Bulla Aldrichi, Langdon.
" n. sp.
Cylichna galba, Con.
Actæon punctatus, Lea.
Tornatella (Tornatellæa) bella, Con.
Tuba antiquata, Con.
Delphinula, sp.
Fissurella Clairbonensis? Lea.
Capulus complectus, Aldr.
Pisania? dubia, Aldr.
Odostomia, sp.
Cornulina armigera, Con.
Oliva bombylis, Con., var.
Nassa cancellata, Lea.
Eulima, 2 sp.
Orbis rotella, Lea.
Ringicula biplicata? Lea.
Hipponyx, sp.
Clavella, sp.
Columbella, n. sp.
Scalaria carinata? Lea.
Crepidula lirata, Con.
Astarte tellinoides, Con.

Astarte Nicklinsii, Lea. Var.
Cytherea perovata? Con.
" Nuttalliopsis, Heilpr.
" minima, Lea.
? Cardita alticosta, Con.
Venericardia planicosta, Lam.
Hippagus isocardioides. Lea.
Corbula Aldrichi, Mr.
" n. sp.
Ostrea (probably O. thirsæ Gabb.)
" sp.
Neæra prima, Aldr.
Leda protexta, Con.
" 2 n. sp.
Pecten Poulsoni, Mor.
" sp.
" (Pleuronectia) n. sp.
Modiola, sp.
Nucula ovula, Lea., var.
Protocardia Nicoletti, Con var.
Lucina subvexa, Con.
" 2 sp.
Tellinia, sp.
Avicula limula, Con.
Pinna, sp.
Mactra, sp.
Diplodonta, sp.
Pteropods, 2 sp.
Cyclosmilia, sp.
Madrepora, sp.
Otolithus, sp.
Nodosaria, sp.
Foraminifera, 2 sp.

A layer 25 feet above the Wood's Bluff beds was found to contain the following species:

Cytherea perovata? Con.
Corbula Aldrichi, Mr.
Lævibuccinum lineatum, Heilpr.
Rostellaria trinodifera, Con.
Leda, n. sp. (same as W. B.).
Nassa cancellata, Lea.

C. Bell's Landing Group.

Voluta Newcombiana, Whitf.
" (Athleta) Tuomeyi, Con.
" Sayana, Con., var.
Fusus trabeatus, Con.
" pagodiformis, Heilpr.
" " var.
" subtenuis, Heilpr.
" subscalarinus, Heilpr.
" (Strepsidura), 2 sp.
" spiniger, Con.
" Meyeri, Aldr.
" rugatus, Aldr.
" 3 sp.
Pleurotoma terebralis, Lam.
" nasuta, Whitf.
" capax, Whitf.
" n. sp. (smooth).
" 4 n. sp.
Turritella Mortoni, Con.
" præcincta, Con.
" bellifera, Aldr.
" multilira, Whitf.
" eurynome, Whitf.
Mesalia vetusta, Con., var.
Potamides Alabamensis. Whitf.
Pseudoliva scalina, Heilpr.
" vetusta, Con.
" elliptica. Whitf.
" tuberculifera, Con.
Turbinella baculus, Aldr.
" pyruloides, Con.
Bulbifusus plenus, Aldr.
" Tuomeyi, Aldr.
Pyrula juvenis, Whitf.
" tricostata, Desh. (Heilprin).
Fulgur triserialis, Whitf.
Cassidaria dubia, Aldr.
Fasciolaria pergracilis, Aldr.
Pyropsis perula, Aldr.
Melongena, n. sp.
Pisania, 2 n. sp.
Cypræa Smithii, Aldr.
Rostellaria trinodifera, Con.
Aphorais gracilis, Aldr.
Trophon, sp.
Murex engonatus? Con.
" 2 sp.
Triton autopsis, Con.
" exilis, Con.
" 2 n. sp.
Trochita trochiformis, Lam.
Nassa cancellata, Lea.
Natica erecta, Whitf.
" Alabamensis, Whitf.
" aperta, Whitf.
" onusta, Whitf.
" perspecta, Whitf.
" parva, Lea., var.

Natica decipiens, Mr.
Natica Mississippiensis, Con., umbilicated var.
Natica sp.
Sigaretus bilix, Con.
" declivis, Con.
Cancellaria, sp.
Oliva gracilis, Lea.
Cadulus, 4 sp.
Dentalium microstria, Heilpr.
Scalaria, n. sp.
Adeorbis depressus, Lea.
Teinostoma subrotunda, Mr.
Solarium elegans, Lea, var.
" delphinuloides, Heilpr.
" scrobiculatum, Con.
Velutina expansa, Whitf.
Cylichna galba, Con.
Bulla, n. sp.
" (Haminea) Aldrichi, Langdon.
Scaphander, n. sp.
Tornatina? sp.
Odostomia, sp.
Chemnitzia trigemmata, Con.
" n. sp.
Eulima notata, Lea.
" ? sp.
Melanopsis anita, Aldr.
" n. sp.
Ringicula, sp.
Cytherea Nuttalliopsis, Heilpr.
" perovata, Con.
Ostrea compressirostra, Say.
" sp?
Pecten, Deshayesii, Lea.
Pecten, 8 n. sp.
Cardium Nicolleti, var.
Modiola, sp.
Avicula limula, Con.
Crassatella tumidula, Whitf.
" sp,
Dosinopsis lenticularis, Rogers.
Lucina compressa, Lea.
" pomilia, Con.
" Claibornensis, Con.
" sp.
Diplodonta, sp.
Tellina, 4 sp.
Arca lima, Con., var.
Cucullæa transversa, Rogers.
Venericardia planicosta, Lam.
" rotunda, Lea., var.
Pectunculus stamineus, Con.
" " var.
Pholas alatoidea, Aldr.
Egeria inflata, Lea.
" plana? Lea.
" subtrigonia, Lea.
" rotunda, Lea.
Leda protexta, Con.
" sp.
Martesia elongata, Aldr.
Panopæa, sp.
Lithodomus Claibornensis, Con.
Corbula engonata, Con.
" Aldrichi, Mr.
" n. sp.
Nucula magnifica, Con.
Cyclosmilia, sp.
Massive Coral.
Nodosaria, sp.

D. Nanafalia Group.

Turritella Mortoni, Con.
" bellifera, Aldr.
" n. sp.
Pseudoliva vetusta, Con.
" scalina, Heilpr.
" erecta, Aldr.
Ancillaria subglobosa, Con.
" n. sp.
Rostellaria trinodifera, Con.
Voluta Sayana, Con.
" Newcombiana, Whitf.
" (Athleta) Tuomeyi, Con.
Volutalithes, sp.
Fusus trabeatus, Con.
" 2 n. sp.
Exilia pergracilis, Con,
Pluerotoma, persa, Whitf.
" terebralis, Lam.
" 2 n. sp.
Natica eminula, Con.
" ætites, Con.
Dentalium thalloides, Con.
Dentalium sp. (smooth).
Cadulus, sp.
Melanopsis Choctawensis, Aldr.
" n sp.
Ringicula, n. sp.
Odostomia, sp.
Bulla. sp.
Venericardia planicosta, Lam,
Gryphæa thirsæ, Gabb.
Pectunculus stamineus, Con.
Crassatella tumidula, Whitf.
Panopæa, sp.
Arca, n. sp.
Cardium Tuomeyi, Aldr.
Corbula Aldrichi Mr.
Tellina, sp.

Nucula ovula, Lea.
Leda, sp.
Cytherea Nuttalliopsis, Heilpr.
Pinna, sp.
Ostrea compressirostra, Say.
Cyclosmilia? sp.

E. Matthew's Landing or Naheola Group.

Murex morulus, Con.
" Matthewsensis, Aldr.
Triton Showalteri, Con.
" n. sp.
Strepsidura, sp.
Fusus tortilis, Whitf.
" Meyeri, Aldr.
" pagodiformis, Heilpr.
" 6 species.
Exilia pergracilis, Con.
Neptunea Matthewsesis, Aldr.
Leucozonia biplicata, Aldr.
Pleurotoma persa, Whitf.
" adeona, Whitf.
" 12 species.
Trochus Alabamensis Aldr.
Solarium, 2 sp.
Pseudoliva unicarinata, Aldr.
" vetusta, Con.
" scalina, Heilpr.
Ancillaria staminea, Con.
Rostellaria velata, Con.
Pyrula juvenis, Whitf.
Volutalithes limosis, Con.
" rugata, Con.
Voluta Showalteri, Aldr.
Lævibuccinum lineatum, Heilpr.
Natica perspecta, Whitf.
" reversa, Whitf.
" Alabamesis, Whitf.
Natica eminula, Con.
" n. sp.
Sigaretus? n. sp.
Melanopsis Choctawensis, Aldr.
Cadulus turgidus, Mr.
Dentalium microstria, Heilpr.
Cerithiopsis, n. sp.
Odostomia, sp.
Eulima, sp.
Rissoina, n. sp.
Ringicula, n. sp.
Cylichna, sp.
Turritella humerosa? Con.
" Alabamensis, Whitf.
" multilira, Whitf.
" Mortoni, Con.
Cucullæa macrodonta, Whitf.
Pecten (Pleuronectia) Alabamensis, Aldr.
Venericardia rotunda, Lea., var.
" Sillimani, Lea.
Corbula, sp.
Leda eborea Con.
Nucula magnifica, Con.
Cardium, sp.
Avicula limula, Con.
Astarte, sp.
Nodosaria, sp.
Coral, sp.

Foraminifera.

The following species of foraminifera from Matthews's Landing have been identified by Dr. Anthony Woodward.

Spiroloculina limbata.
Clavulina cylindrica.
Nodosaria affinis.
" bacillum.
" badenensis.
" filiformis.
" raphanistrum.
" vertebralis.
Cristellaria calcar.
" elegans.
" rotulata.
" Wetherellii.
Polymorphinia compressa.
" elegantissima.
" gibba.
" problema.

F. Black Bluff or Sucarnochee Group.

Nautilus, n. sp. (fragments).
Exilia pergracilis, Con.
Mitra, n. sp.
Aphorais gracilis, Aldr.
Ancillaria, sp.
Pleurotoma, 2 sp.
Fusus, 2 sp.
Cadulus turgidus, Mr.
Volutalithes rugata, Con.
Dentalium, sp.
Tornatella bella, Con.
Pecten (Pleuronectia) Alabamensis, Aldr.
Cucullæa macrodonta, Whitf.
Nucula magnifica, Con.
Leda, n. sp.
Coral, sp.
Crab remains, (abundant).
Forminifera, 2 sp.

THE (MIDWAY) CLAYTON TERTIARY SECTION AND ITS FOSSILS.

By T. H. Aldrich.

This section lies at the base of the Tertiary of Alabama and adjoining states, and is especially interesting from its position and fossil contents.

Dr. E. A. Smith, State Geologist of Alabama, in 1883–4,* named this section the "Midway or Pine Barren Section," but has subsequently (Geological Map of Alabama, 1894,) changed this name to "Clayton" because the formation is developed near the town of Clayton, Alabama, to a thickness of over 220 feet, and is therefore much more typical than the locality from which the first name was adopted.† The section at Midway and in Wilcox county, Alabama, on Pine Barren Creek, is as follows, beginning at the top.

(1.) 10 feet white limestone.

(2.) 6 feet calcareous sands.

(3.) 9 feet yellow crystalline limestone.

A recent visit to the localities in Wilcox county has resulted in our finding nothing but the *Enclimatoceras Ulrichi, White*, in the upper layer called the Nautilus rock. The other two layers are hardly separable and contain the fossils. They are in places crowded with fossils, but the forms are broken and silicified, so that perfect specimens are rare. Nearly all the specimens recorded from Wilcox county, as at Prairie Creek, near Allenton, &c., are found on the hills in and near to the plantation of W. W. McConnico, Esq. We are greatly indebted to Mr. McConnico for pointing out the various outcrops, and for assistance in collecting.

* Bulletin No. 43, U. S. Geol. Survey.

† D. W. Langdon, Jr., Geol. Soc. American Bulletin, vol. 2, pp. 587-605, 1891.

The writer in Bulletin No. 1, Geol. Survey of Ala., p. 60, 1886, listed the few fossils then known as follows:

(1.) Midway bed:

ENCLIMATOCERAS ULRICHI, White.

(2.) Turritella rock:

TURRITELLA MORTONI, Con.

" HUMEROSA, Con.

VENERICARDIA PLANICOSTA, Lam.

OSTREA, 2 sp.

CORAL, 2 sp.

Some four years ago Dr. Smith put into my hands for examination and study a collection of fossils from this formation much larger and more complete than heretofore known. Dr. W. H. Dall also sent part of the collection from the National Museum; these, together with some collections made in person, constitute the material used to prepare the list given below.

The writer desires to call attention to a formation at the base of the Tertiary in France and Belgium called the "calcaire pisolithique," which is a yellow limestone resting on the Cretaceous and has a fossil series strikingly similar to ours. It has two species of Nautilus, a Trochus, large Cerithia, a Crassatella, Ostrea, &c.

Mr. G. D. Harris, in American Jour. of Science, April, 1894, has lately proposed to unite the Matthews's Landing marl, Black Bluff clays, and the Midway limestone and clays, in one stage as Midway, and the fossils to a certain extent bear out the grouping, but further explorations must be made before any conclusion should be accepted as final, because the new species described below are not known in either of the other higher divisions mentioned. The corals are also distinctive.

All the species are from the vicinity of Prairie Creek and Mr. McConnico's plantation, unless otherwise stated.

List of Species.

1. CRASSATELLA TUMIDULA, Whitfield.

2. VENERICARDIA PLANICOSTA, Lam., Pl. XII, fig. 3.

All the specimens are small, with exceedingly flat ribs; that figured is natural size.

3. CUCULLÆA TRANSVERSA, Rogers.

One perfect specimen, many fragments.

4. CYTHEREA NUTTALLIOPSIS, Heilprin.

There are some specimens that show differences in dentition and may indicate another species.

5. CYTHEREA, sp.?

A young shell, ribbed, but too poor for description.

6. OSTREA TUMIDULA, n. sp., pl. XIV, figs. 1 and 2; pl. XV, figs. 1 and 2.

Shell large, rather solid, lower valve convex, upper valve flat or nearly so; beaks turned to left and pointed; lower valve plicated and imbricated, varying considerably however with age; upper valve in some cases imbricated, in others showing merely lines of growth. Muscular scar large, on left side, and distant from beaks; inner edge of upper valve marked with tubercles; attachment scar large; lower valve expanding beyond the upper valve, ligamental area not large.

This oyster is the most abundant fossil in the Turritella bed; it is subject however to considerable variation. The figure of the upper valve is broader than usually found; sometimes on very old specimens the fluting is nearly obsolete.

The figures are a little larger than natural size. The younger forms resemble *O. compressirostra*, Say, young. Types from Geol. Survey collections—several specimens in the collection from Midway, Alabama.

VENERICARDIA SMITHII, n. sp., pl. XII, figs. 1, 1a., 1b.

Shell large, solid, slightly transverse, inflated, inquilateral, strongly ribbed, beaks strongly recurved, elevated; ribs 32–35 on specimens figured, flat in central part, strongly tuberculated, both on the anterior and posterior, more faintly marked on the central part; teeth nearly transverse, cavity of shell deep, margin crenulate, cicatrices slightly impressed.

The drawings are slightly larger than the shells. The general outline of this species is like *V. planicosta*, Lam., with which it is associated and of which a figure is also given.

Differs from *V. alticostata*, Con., (*transversa*, Lea.,) in the flatness of the ribs. Fig. 1 is from a specimen in my collection, the other (1b.) is in the state collection. Rather abundant. Named in honor of Dr. Eug. A. Smith.

8. LYRIA WILCOXIANA, n. sp., pl. XII, fig. 4.

Shell rounded fusiform, whorls four, spire blunt, first three whorls smooth, body whorl transversely ribbed, the ribs rather sharp with concave spaces; no spiral sculpture shown; suture distinct, not deeply impressed; body whorl long terminating in a canal, which is missing in specimen figured; aperture long and narrow, inner lip showing a few plications, but the aperture is filled in so that the lips are almost completely hidden.

Specimen is partially silicified. Prof. Dall refers to this species, but without describing it in Trans. Wagner Free. Inst. Science, vol. 3, p. 69. Type in National Museum.

9. ROSTELLARIA (CALYPTRAPHORUS) VELATA, Con., var. COMPRESSA, n. var. pl. XII, figs. 2, 2a, 2b.

This form is intermediate between *R. trinodifera*, Con., and *R. velata*, Con. The adult has the enamel on the front part as in *R. trinodifera*, but on the opposite side the line of demarkation of the enamel comes down only to the whorl. The specimens are also much smaller than the normal adult. A similar form that cannot be separated from this variety is common in the Matthews's Landing group but is nearly twice as large, more rotund than those figured. The figures given are somewhat larger than the types. Below is a list of all the species of Rostellaria known from the Eocene.

Genus. ROSTELLARIA. Lam.

Subgenus. HIPPOCRENES. Montf.

(1.) R. EXTENTA, Conrad. P. A. N. S., Phila. p. 260; *Aporrhais* (*Platyoptera*) *extenta*, Con., Wailes Geol. of Miss. pl. 16, fig. 3; 1854.

(2.) COLUMBARIA. DeFrance, Conrad. P. A. N. S., Phila. p. 73; 1865.

Subgenus. RIMELLA. Ag.

(3.) R. LAQUEATA, Con. Foss. Shells Tertiary, pt. 4, p. 41, 1833; pt. 3, 2d Ed. p. 38, pl. 15, fig. 5; 1835.

Cuvieri, Lea. Contr. to Geol., p. 160, pl. 5, fig. 165. Nov. 1833.

Strombus canalis, Lam. DeGregorio, Mon. Eocene. Ala. p. 113, pl. 9, figs. 16, 17, 18, 19; 1890.

(4.) R. SMITHII, Dall. Trans. Wagner F. Inst. Sc., p. 172, pl. 10, figs. 4 and 6; 1890.

Subgenus. LEIORHINUS. Gabb.

(5.) R. PRORUTA, Con. Foss. Shells Tert. No. 3, 2d Ed. p. 51, pl. 17, fig. 15; 1835.

Leiorhinus crassilabris, Gabb. Jour. Acad. Nat. Sc. vol. 4, 2d ser. p. 402, pl. 67, fig. 60; 1860.

Leiorhinus proruta, Con. Am. Jour. Conch. p. 30; 1865.

Strombus (*Leiorhinus*) *prorutus*, Con. DeGregorio, Mon. Eoc. Ala. p. 114, pl. 9, fig. 20; 1890.

Subgenus. CALYPTRAPHORUS. Con.

(6.) R. VELATA, Con. F. S. Tert. 1st Ed. No. 3, p. 31. Aug. 1833.

Lamarckii, Lea. Contr, to Geol. p. 158, pl. 5, fig. 164; 1833.

Staminea, Con. P. A. N. Sc., Phila. p. 260; 1855.

Quidest, DeGregorio, Mon. Eoc. Ala. p. 115, pl. 10, figs. 1, 2a, b; 1890.

(7.) ROSTELLARIA VELATA, Con., var. COMPRESSA. Aldr. this paper.

(8.) R. TRINODIFERA, Con. Proc. A. N. Sc., Phila. p. 166; 1857. Jour. A. N. Sc., Phila. p. 298, pl. 47, fig. 29; 1858–60.

In Wailes's Geology of Mississippi the specific name of *R. velata* is spelled VELLATA, which is evidently a misprint. In the Smithsonian check list of 1868 Conrad gives *Calyptraphorus eburneus*, Con., but this must be simply a list name. *Rostellaria Whitfieldi*, Heilpr, is a Cerithium.

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10. VOLUTALITHES LYROIDEA, n. sp., pl. XIII, fig. 7.

Shell short fusiform, surface strongly ribbed with about eight plications ending rather abruptly at suture, giving the shell a shouldered appearance, no spiral lines observable, surface smooth, suture strongly impressed, spire missing in the type. The ribs are not continuous from one whorl to the other but alternate; body whorl large, ending in a short recurved canal. Aperture oblong.

This species has a general resemblance to *Volutalithes rugata*, Con., but lacks the long canal, and has no spiral sculpture. The aperture is too imperfect to determine the exact generic position. It may turn out to be a *Lyria*.

Length of part remaining 30 m. m.; breadth 14 m. m. Type in National Museum.

11. CERITHIUM CLAYTONENSE, n. sp., pl. XIII, figs. 1, 1a, 1b.

Shell large, rapidly tapering, whorls remaining, thirteen, each banded by a broad nodulous raised space alternating with four to five deeply cut spiral lines, sometimes showing a fine raised line in the depressions, columella showing internally two plications between the whorls.

No perfect specimens yet found but the species is very distinct and much larger than any hitherto known from our Eocene. Length of largest specimen 125 m. m. Specimen showing internal structure from the National Museum; the other from the State Survey Collections.

12. PSEUDOLIVA SCALINA, Heilpr. On road through Mr. McConnico's plantation.

13. TURRITELLA ALABAMENSIS, Whitfield, pl. XIII, fig. 2. A variety without the spiral raised lines.

14. TURRITELLA MORTONI, Con. One young example.

15. TURRITELLA HUMEROSA, Con., var. multileia, Whitfield. Pl. XIII, fig. 3.

16. TURRITELLA HUMEROSA, Con., var. Pl. XIII, fig. 5.

This protean species has so many variations it would be difficult to illustrate them all.

17. TURRITELLA ALLENTONENSIS, n. sp., pl. XIII, 4a.

Whorls rounded and covered with close set fine spiral lines, a corded space below the suture followed by a concave space, the middle of the whorl with another depressd space;

below this a raised space with two fine spiral lines on the periphery of same, then a concave area to the suture. Only fragmentary examples found. The young shell figured pl. XIII, fig. 6, is probably this species. My collection.

18. TURRITELLA WILCOXIANA, n. sp., pl. XIII, fig. 4b.

Suture impressed, bounded by an angular space above and below, whorls with the general shape of *T. Mortoni*, Con., a raised cord below the suture, then two equidistant raised spaces, then another raised cord followed by a slightly concave space to suture. No perfect specimen found. My collection.

19. PLEUROTOMARIA? sp.?

Among the collection is a cast resembling from its shape and patches of ornamentation the above genus. I note it here with the hope future collectors may get more perfect specimens.—From State Museum.

20. NATICA, sp.?

Two specimens found. One cast.

21. TEREDO, sp.?

None with characters distinct enough for description.

22. ENCLIMATOCERAS ULRICHI, White.

Found only in the Nautilus rock.

23. SCAPHELLA (CARICELLA) LEANA, Dall., Trans. Wagner, Fr. Inst. vol. 3, p. 86, pl. VI, fig. 9; 1890.

In addition to the above species, a fragment of a *Pleurotoma* and of a *Caricella* close to *C. pyruloides*, Con., are in the collection.

The corals of this group are nearly all peculiar to this horizon. Mr. T. Wayland Vaughn has gone over the series and has kindly given me the following list:

24. CÆSPITOSE ASTRÆAN, Vaughn.

Turritella rock.

25. STEPHANOCŒNIA MONTICULIFORMIS, Vaughn.

Turritella Rock and Prairie Creek, Alabama.

26. FLABELLUM CONOIDEUM, Vaughn.

Grave Yard Hill, Prairie Creek and Matthews's Landing, This is very doubtful, as the localities are *not* those of the Turritella rock and the writer does not know of a single example ever found below the Black Bluff clays.

27. SIDERASTRÆA HEXAGONALIS, Vaughn.

Prairie Creek, Alabama.

28. THAMASTRÆA DUNCANI, Vaughn.

Prairie Creek, Alabama.

The above list constitutes everything known from the horizon under examination. Nothing has been collected from the eastern part of the state except *Ostrea tumidula*, Aldr., and some unrecognizable casts. The beds need more careful examination as they are already known in Arkansas, Tennessee, Mississippi, Alabama and Georgia and will always be a horizon for paleontologists as well as the student of stratigraphy to start from.

In Tennessee Dr. Safford has recently named this series the "Middleton."

1a

1

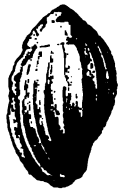
2

1b

2a

2b

3.



4.

Fig. 1, 1a, 1b—Venericardia Smithii. Aldr. Fig. 2. 2a, 2b—Rostellaria velata. Con
Fig. 3. Venericardia planicosta. Lam. Fig. 4. Lyria Wilcoxiana. Aldr.

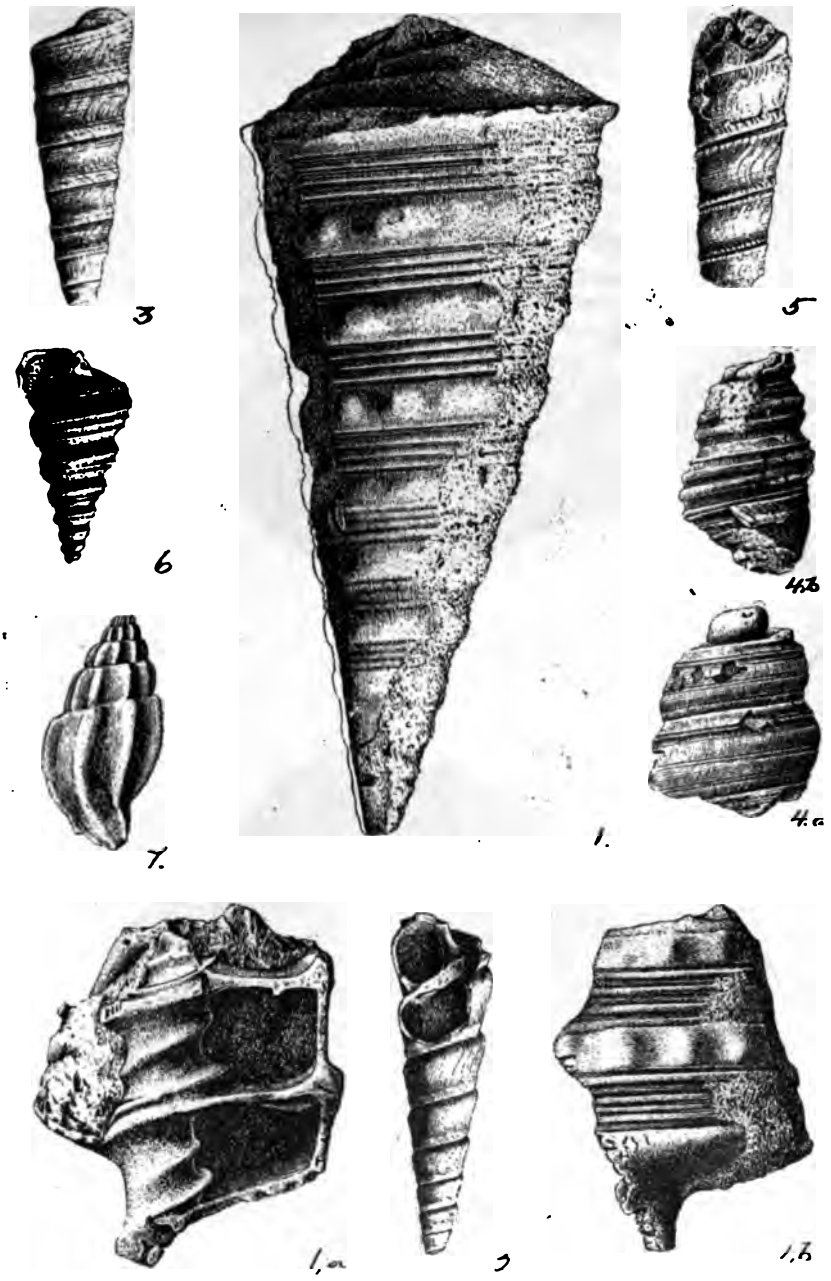
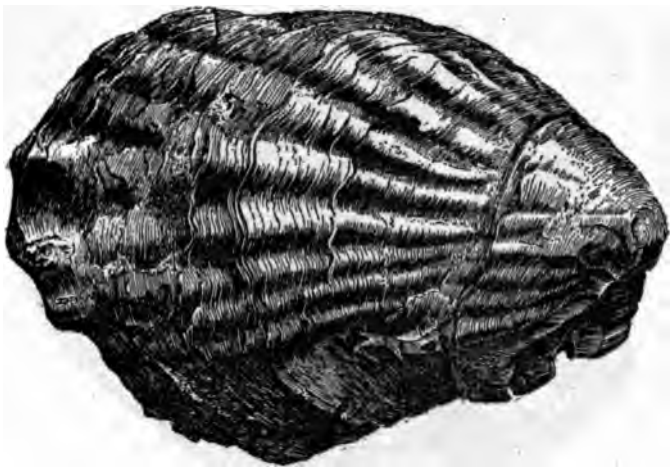
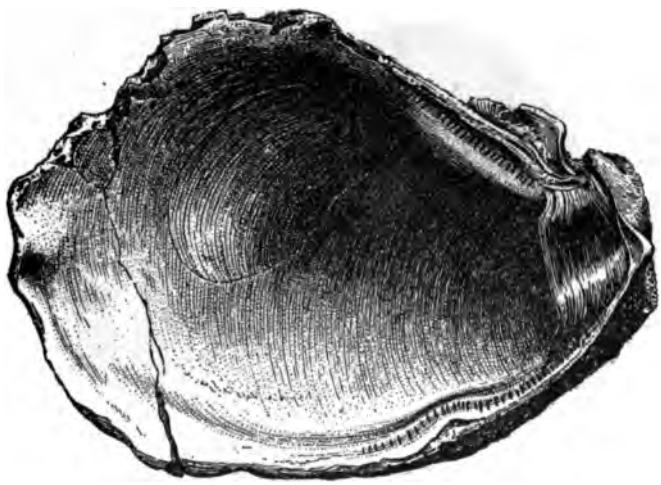


FIG. 1, 1a, 1b. Cerithium Claytonense. Aldr. FIG. 2. Turritella Alabamensis. Whitf. FIG. 3. Turritella humerosa, Con var. multilcia. Whitf. FIG. 4a. Turritella Allentonensis. Aldr. FIG. 4b. Turritella Wilcoxiana. Aldr. FIG. 5. Turritella humerosa. Con Variety. FIG. 6. Turritella Allentonensis (Young.) FIG. 7. Volutalithes lyroidea. Aldr.



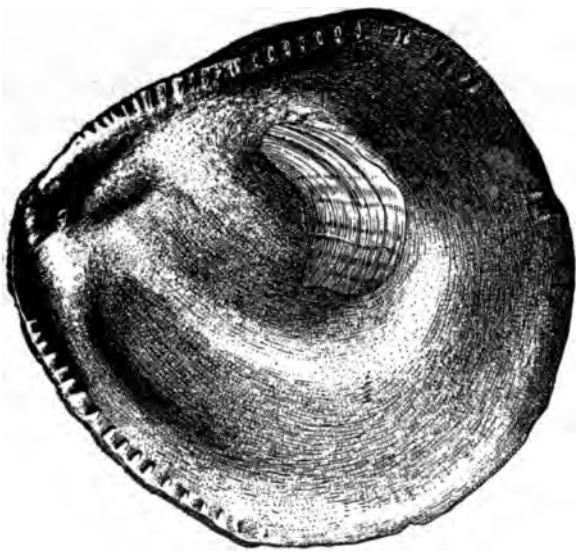
1.



2.

FIG. 1 & 2. Ostrea tumidula. Aldr.

1



2

MICROSCOPIC SPECIES.

In addition to the shells above enumerated many species of foraminifera, radiolaria and diatoms have been identified, chiefly through the energy of Mr. K. M. Cunningham, from material of the Claiborne and Buhrstone age. The following species identified by Dr. Anthony Woodward, come from the Claiborne beds at and near the landing of that name:

Eocene Foraminifera from Claiborne.

Miliolina agglutinans,
" bicornis,
Textularia agglutinans,
" Barrettii,
" conica,
" gramen,
" sagittula,
Clavulina communis,
" cylindrica,
Bolivinia textularioides,
Lagena aspera.
Cristellaria italica,
Cristellaria calcar,
" rotulata,
" nitida,
Polymorphina angusta,
" communis,
" complanata,
" gubba,
Uvigerina angulosa,
Truncatulina Haidingeri,
" refulgens,
Rotalia beccarii,
" soldanii,
Nonionina depressula,
" umbilicatula.

Tripoli from the Buhrstone.—Mr. Cunningham discovered among the Buhrstone rocks at Enterprise, Mississippi, some light, porous, clay-like rocks which, upon examination under the microscope, proved to be in large part made up of the silicious shells of *foraminifera*, *diatoms*, *radiolaria*, etc. Afterwards from specimens blasted up from the McGrue shoals, a short distance above St. Stephens, he was able to show that this formation extended into Alabama also. A microscopic analysis showed that the light silicious clay stratum was essentially composed of marine species of diatoms, foraminifera, polycistines, sponge spicules and gemmules, all of which were metamorphosed or altered through the agency of mineral infiltrations. Where this rock is below the water level it is riddled with the holes made by the

willow fly in which the grub of the fly undergoes its metamorphosis. Species of marine Diatoms of the following genera were noted, *Coscinodiscus*, large and small, *Actinocyclus*, *Melosira*, *Triceratium*, three and four sided species, *Cyclotella* and *Biddulphia*. Several species of the following genera of Polycistines or Radiolaria, viz., *Ethmosphæra*, *Haliomma*, *Actinoma*, *Stylosphæra*, and *Ellipsostylus*, and numerous species of Foraminiferæ of the genera *Rotalia*, *Textularia*, and *Lagena*. The deposit is very rich but identification of the species is rendered difficult or impossible by the metamorphic action of the saline substances, chiefly gypsum or sulphate of lime, which has largely obscured the specific sculptural markings of the shells.

The following notes by Mr. Cunningham upon the microscopic forms identified by him in the materials of the different horizons of our Tertiary formations, will be found of interest, and they present in connected form the results of his recent sudies in this field.

NOTES ON THE MICROZOA OF THE TERTIARY OF SOUTH ALABAMA.

By K. M. Cunningham.

In the prevalent scientific classification of the Animal Kingdom, we find the Protozoa occupying the lowest position. Under this term are united various orders of microscopic animal organisms, characterized by relatively elementary and simple structural features. The Protozoa are divided into four classes: (1) the *Monera*, (without any apparent organs). (2) the *Rhizopoda*, having a nucleus and an outer layer of sarcode. (3) the *Gregarinæ*, an ovate animal parasite; and (4) the *Infusoria* (having a definite shape, and usually one or more mouths). The last named holds the highest place in the quartette.

It is with Class 2 that students of micro-geology are more particularly interested, and it also suggests the motive for these notes and observations. Class 2, Rhizopoda, may be further divided into the following orders: *Foraminifera*, *Lobosa*, *Heliozoa*, and *Radiolaria*. Intimately associated with these orders we may add the Diatomaceæ, which were, in the earlier views of the German Naturalists, including C. G. Ehrenberg, classed among the Infusoria, while the generally ac-

cepted opinion of the present time places them in the Vegetable Kingdom, in the class of Algæ.

Still, there are many naturalists who at the present day continue to regard the Diatomaceæ as belonging to the animal kingdom, among these is Prof. Ernst Haeckel. As late as July 9th, 1894, I have been enabled to gather the proof requisite to the successful demonstration of the fact that the Diatomaceæ of recent fresh water and salt water sources properly belong to animal life, and should therefore be classed among the Protozoa. The final proof of this has been derived from living Diatoms growing in the fresh water lakes at the Jesuits' College at Spring Hill, distant six miles from Mobile, Ala. The full and complete method of demonstration will be published in the American Microscopical Journal, of Washington, D. C., where all who may be inclined to do so, may verify the biological phenomena upon which the proof of their animal nature is based.

The state of Alabama is particularly rich in strata belonging to different geological epochs, which are almost entirely built up of the fossilized skeletal remains of the Rhizopoda. Thus the chalk of the Cretaceous formation, as below shown, has as much as 75 per cent. of microscopic foraminiferal shells in its composition, and this chalk stratum has been penetrated by artesian borings continuously to a depth of more than 900 feet. Again, in the Clayton division of the Eocene Tertiary, we have recently examined two varieties of so-called clays, one of which is a radiolarian clay, and the other a marine diatomaceous clay, with fragments of *coscinodiscus*, *melosira*, and other discoidal forms of diatoms, together with millions of fragments of silicious sponge spicules. In both specimens there is a large percentage of fine amorphous silicious matter or clay.

Above this geologically, in the Matthews's Landing clays, we find a number of species of foraminifera identified by Mr. Woodward. But within the area covered by the Buhrstone or Lower Claiborne, strata of marine silicious clays of great thickness are known to exist, in which the fossilized and minerally metamorphosed skeletal remains of Diatomaceæ, Radiolaria, and Foraminifera, along with silicious sponge spicules occur in extraordinary richness, as attested by repeated microscopic analysis of the tripoli occurring in the vicinity of Big McGrue Shoals on the Tombigbee river, about one and a half miles above St. Stephens, Ala. In numerous examinations of this material species of fossils Radiolaria have been noted, viz., *Cenosphæra*, *Ethmosphæra*, *Haliomma*, *Actinoma*, *Stylosphæra*, and *Ellipsostylus*, as determined by Rev. Fred. D. Carter of Montclair, N. J. Also species of marine diatoms of the following genera: *Coscinodiscus*, *Antinocyclus*, *Melosira*, *Triceratium* of three and four linear sides, as well as Foraminifera of the genera *Textularia*, *Rotalia*, and *Lagena*, with sponge spicules of the triradiate and polyradiate marine species. The metamorphism or mineralogical change of these fossil microzoa, seems to

have been through an infiltration of sulphate of lime or gypsum, which is also characteristic of the metamorphism of the marine clays of the Paris Basin.

While I had several years previously recorded the occurrence of marine diatoms, foraminifera, and radiolaria from the marine tripolis of Clarke county, Miss. (Buhrstone horizon), I have quite recently and in a more positive manner, been enabled to prove the occurrence of a very rich deposit of radiolaria and marine sponge spicules in strata situated a few miles south of Meridian Miss., which radiolarian tripoli is scarcely inferior to the well known radiolarin chalk of the Island of Barbadoes, one of the West Indies. The date of this most recent find was June 25, 1894. I have also determined the occurrence of the radiolaria in specimens ol marine tripoli derived from the Buhrstone formation in Sumter, Choctaw, Clarke, and Covington counties, and most recently at Clayton in Barbour county, so that the the distribution of deposits of this character in Alabama seems to be very wide. Fossil radiolarian deposits have within the past few years been found in the northwest corner of Monitoba, while like deposits have been known to exist at Barbadoes for many years, and they are also found in the Nicobar islands. They are likewise to a greater or less extent associated with the marine clays of Miocene age in many parts of the globe. I have reason to believe that the first recorded instances of the occurrence of radiolarian deposits in the United States, have been in the Eocene and the Miocene of the Southern States, as a result of my personal interest in the study of the microscopic structure of the roks in this section.

Mineralized fossil marine Diatoms.—Pyritized Diatoms had been known as occurring in the marine clays of the London basin for a number of years past; but my own observations have enabled me to extend very materially the known area of their distribution. In the year 1892, while on a visit to Galveston, Texas, I examined the clays dredged by suction from a depth between 25 and 30 feet in the bay, and from this clay I was enabled to report the occurrence of mineralized, i. e., *pyritized* diatoms of the genera *Coscinodiscus*, and *Triceratium*, and species of pyritized foraminifera. In the same year, while examining the clays derived from five artesian wells drilled in and around Mobile, Alabama, I was able to identify in them pyritized diatoms of the following genera: *Coscinodiscus*, *Actinocyclus*, *Orthosira*, *Pleurosigma*, *Navicula* and *Synedra*. These diatomaceous and foraminiferal clays which came from an average depth of 650 feet were associated with a stratum containing thousands of a minute bivalve shell ranging in size from one-tenth to one-quarter of an inch in length. Dr. Wm. H. Dall has named this shell, hitherto unknown, *Gnathodon Johnsoni*, after Mr. L. C. Johnson, who discovered a series of fossiliferous strata of Miocene age, near the town of Vernal, in Mississippi, to which strata he has given the name used above in this report, viz.,

Pascagoula. With the gnathodon occur also a few oysters, large fragments of shells of which have been brought up from the borings, together with a small gasteropod resembling a cerithium. Dr. Dall concludes from the evidence of these shells that the deposit containing them is of Miocene age, while Prof. Woodward as early as 1892, had identified the eight or more species of foraminifera derived from this same marl, as of Miocene age.

Among the many fossiliferous strata occurring within the area of the state of Alabama, one of the most interesting and one celebrated in geological literature for more than half a century, is found in the vicinity of St. Stephens on the Tombigbee river. This is a rock composed almost entirely of remains of fossil species of microscopic corals, bryozoans, and foraminiferal shells of various sizes, and known as the *Orbitoidal limestone* from the foraminiferal shell *Orbitoides Mantelli*, which occurs in it in the greatest abundance. These shells vary in size from that of a pin's head to as much as an inch and a half in diameter. They are circular or discoidal in shape, with small nodular inflations or prominences at the central axis, at which point also is situated the largest cell or chamber of the whole series. From this center a very large number of concentric circles of minute cells spread out on its median plane and the layer of median cells is covered by numerous superficial layers and zones of branching channels, communicating with the larger cells and variously anastomosing, and all the cells or chambers have their walls traversed by microscopic pores, specifically known as *foramina* (foramen), from which character the order "Foraminifera" derives its name. The foraminifera while usually of minute size have yet contributed in an extraordinary manner to the formation of the earth's crust, as below noted under Chalk. In studying the minute structure of Orbitoides Mantelli, by means of thin sections it is found that from the central chamber or core-cell innumerable small cells spread out in a regular decussating series of concentric circles, with an almost geometrical precision, suggestive of lathe-work chasing. This arrangement is characteristic of many species of fossil and recent Diatoms. The cells constituting the median layer of Orbitoides may number from a few hundred to several thousand in a single discoidal specimen. It has been observed in recent species of foraminifera from the Mediterranean Sea, *O. complanatus*, that the outer test or shell of carbonate of lime may be dissolved away by acids, leaving the protoplasmic cell contents as a multitude of little balls of protoplasm attached to one another by a stolon of the same substance. So the calcareous foraminiferal species of this deposit, having the cell contents silicified, yield by treatment with acids, silicious or flinty casts or moulds of the original protoplasmic mass once occupying the chambers of the shells. From such preparations we may study the different arrangements of the cells

...S FORMATIONS.

...AL CHARACTERS.

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...pure argillaceous limestone of tolerably ...tion and about one thousand feet in thick- ... the Rotten Limestone heretofore, but for ...se the name Selma Chalk, for reasons given

...series of laminated sands and sandy clays at ...ndred feet in thickness, which has been named ...ormation.

A great series at least one thousand feet in ...f variously colored sands, laminated and massive ...e of which hold impressions of leaves in great ... and sometimes in a state of preservation perfect as ...and markings. To this series, which is in part at ...nivalent to the Potomac of Mr. McGee, we have ...e name of the Tuscaloosa formation.

...subdivision applies to that part of the state adjacent ...Tombigbee and Alabama rivers, but coming eastward ...ntgomery we find that the Selma chalk loses its dis- ...e characters and cannot be recognized eastward of the

which characterize the foraminifera of the Rotaline and Textularian orders.

The minute corralline branches and stems that abound in the Orbitoidal limestone represent many distinct species, and show a great diversity in their surface markings and ornamentation.

In addition to the above, we find in this rock a great number of silicious sponge spicules, easily isolated by the removal by acids of the carbonate of lime, which makes the great mass of the rock.

Although not bearing directly upon Alabama, I should like to refer to my late discovery of a marine fossil Diatomaceous clay occurring within a radius of thirty miles of Tampa, Florida. In this material I have identified species of the following genera of the Diatomaceæ, viz., *Coscinodiscus*, *Actinoptychus*, *Actinocyclus*, *Biddulphia*, *Melosira*, *Craspedodiscus*, *Triceratium* of three and four sides, *Raphoneis*, *Sceptoneis*, and others, the character of the clay agreeing in a general way with the celebrated fossil deposits of the Atlantic coast Miocene clays. This diatomaceous clay of the phosphatic rock area of Florida, is of the same age with the Richmond, Virginia, fossil clays, i. e., Miocene, and associated with the infusorial stratum were Radiolarians and marine sponge spicules.

In Bulletin No. 84 of the United States Geological Survey, "Correlation papers—Neocene," Dr. Dall discusses, in a limited way, the fossil diatomaceous deposits, of both marine and fresh water origin, belonging to the Tertiary system of the United States, but does not mention the occurrence of the diatomaceous clays of Florida, which I had independently worked out and placed on record in various ways during the spring of 1893. By the discovery of fossil diatoms of Miocene age on the western coast of Florida, several problems of geological interest have had material light thrown upon them. These data will be of use in subsequent discussions of the occurrence and distribution of the Miocene deposits of the Southern States bordering the Atlantic and Gulf coasts.

In conclusion. it might be appropriate to state that the bays and beaches of the Gulf coast furnish a rich fauna of living microscopical foraminiferal organisms, since from the beach sands at Galveston Bay, along the public Gulf shore drive, it is possible to isolate millions of pure foraminiferal shells which are washed in at every pulsation of the waves of the Gulf, and are piled up in whitish ripple lines on the gently sloping drive.

CRETACEOUS FORMATIONS.

GENERAL CHARACTERS.

The Cretaceous formation in Alabama exhibits four well marked divisions which, in descending order, are as follows:

First. A series of dark gray or bluish, sandy, micaceous clays which weather into yellow micaceous sands; impure limestones with many casts of fossils; then sandy strata again; in all between two and three hundred feet in thickness. This has been called the Ripley formation by Dr. Hilgard, and the name is retained for Alabama.

Second. An impure argillaceous limestone of tolerably uniform composition and about one thousand feet in thickness, known as the Rotten Limestone heretofore, but for which we propose the name Selma Chalk, for reasons given below.

Third. A series of laminated sands and sandy clays at least three hundred feet in thickness, which has been named the Eutaw formation.

Fourth. A great series at least one thousand feet in thickness, of variously colored sands, laminated and massive clays, some of which hold impressions of leaves in great numbers, and sometimes in a state of preservation perfect as to form and markings. To this series, which is in part at least equivalent to the Potomac of Mr. McGee, we have given the name of the Tuscaloosa formation.

This subdivision applies to that part of the state adjacent to the Tombigbee and Alabama rivers, but coming eastward of Montgomery we find that the Selma chalk loses its distinctive characters and cannot be recognized eastward of the

central part of Macon county, while strata of the general physical appearance of the Ripley, with somewhat modified characteristics as will appear, seem to replace both the Rotten Limestone and the Ripley of the western part of the state.

East of the longitude of Montgomery, the Tuscaloosa formation also occupies a much narrower belt than further west, and the Eutaw has not been so clearly discriminated from it, and from the Ripley which here immediately succeeds it going southward.

Along the eastern border of the state the succession of the Cretaceous strata is about as follows:

First. A great series of bluish micaceous sandy clays, gray clayey sands, with beds of beautifully preserved shells, and indurated ledges also usually containing shells, mostly of oysters; massive blue clays sometimes with lignitic matter, making the country along the Chattahoochee river for a distance of 35 to 40 miles, and, with estimated uniform dip of the strata of 35 to 40 feet to the mile, corresponding to a thickness of 1,000 feet or more. These beds, or at least the upper half of them, contain fossils characteristic of the Ripley division of the Cretaceous, and, strangely enough, resemble those occurring in the similar blue micaceous clays of Owl creek near Ripley, Mississippi. Between these two extremes in East Alabama and North Mississippi, these blue marls with well preserved shells are not at all common, and the Ripley fossils, except the members of the oyster family, are seen chiefly in the form of moulds or casts.

Second. A series of cross-bedded sands with clay partings, the latter, especially when thick, containing many fragments of lignitized stems and leaves, and occasionally large logs also lignitized; dark colored micaceous sands with ledges holding fossils, chiefly oysters; nearly black somewhat sandy clays and clayey sands with many fossils mainly in the form of casts. These beds have a thickness

of at least 400 feet along the river. The fossils of this series, in so far as they have any distinctive character, seem to be closely related to the species occurring in the upper part of our Eutaw sands.

Third. The cross-bedded sands, mottled clays, gray clays, and other characteristic materials of the Tuscaloosa formation, which extend from Broken Arrow Bend, eight miles below the city, up the river to Columbus, and perhaps further. This will correspond to a thickness of 300 to 350 feet at least. The river banks above Columbus have not been examined, but it seems very probable that the thickness of the Tuscaloosa beds in the eastern part of the state is much less than further west, and certainly the width of the outcrop east of Montgomery is insignificant compared with the outcrop west and northwest of that point.

All these strata, especially the calcareous ones, are more or less perfectly exhibited along the banks of the two rivers of Western Alabama as well as along the Chattahoochee.

It will be seen below that we have not as yet been able to construct the column of strata of this formation with as great a degree of completeness as has been done for the Tertiary, but the uncertainty is in regard to the relative thickness of the several strata rather than to the succession and quality of these beds.

SUBDIVISIONS.

1. The Ripley Formation.

The character of the uppermost beds of this formation immediately underlying the Tertiary was first clearly determined by Mr. Johnson in the Pine Barren section, in the eastern part of Wilcox county, already given above. These uppermost beds were afterwards traced by him westward to the Alabama River and eastward to Clayton and Eufaula.

The relation of the Bridgeport horizon to the yellow sands was also first determined by him. In 1885 the strata connecting the Bridgeport section with the Prairie Bluff section were determined by Mr. Langdon and myself, and it is believed that we now have the complete section of the Ripley strata along the Alabama and Tombigbee rivers, except that the actual contact with the Rotten Limestone of the sands forming the lower part of Prairie Bluff, has not come under observation. The uppermost beds of this formation were also examined in 1885 by Mr. Langdon and myself in Marengo county, south of Dayton, as described below.

Subsequently Mr. Langdon examined the country east of the Alabama river to the Georgia line and made a section of the strata exposed along the Chattahoochee as will be seen in his paper below, and in 1890 and 1891 in a boat trip down the Chattahoochee, and from Tuscaloosa to Greensboro, Marion, Prattville, Wetumpka, Notasulga, etc., to Columbus, Ga., and then on down the river by land, I was able to add a good many notes to these formations. We have thus a fairly correct column of these beds along the Chattahoochee as well as of their characteristics east of the Tombigbee and Alabama rivers.

Inasmuch as the Cretaceous strata in the vicinity of the Tombigbee and Alabama rivers, differ in many respects very widely from those exposed along the eastern border of the State, we shall perhaps be able to give a better idea of the formation by describing the occurrences in the region adjacent to the two rivers first named, and then point out the variations which are to be observed as we go east, giving at the end the sections along the Chattahoochee.

THE RIPLEY, NEAR ALABAMA AND TOMBIGBEE RIVERS.

The strata of the Ripley in this part of the State are :

First. About one hundred and fifty feet of bluish micaceous sandy clays, somewhat calcareous, marked at intervals

of ten or fifteen feet throughout the whole thickness by the occurrence of indurated ledges usually of rather sandier texture. These ledges appear occasionally as shaly sandstones of very little hardness, flaking off readily into thin sheets under the action of the weather. These sandy beds hold a few of the most common fossils of the Cretaceous formation. Where they lie high above the drainage level and well exposed to the influences of the weather, they assume a yellow color and lose in great measure their coherence, becoming a mass of yellow sands, at times retaining their structure, but often appearing as loose micaceous sands. The transition from the bluish gray materials to the yellow sands has been observed by us in many localities in the Canton Bend, in the hills between Prairie Bluff and Rehobeth, also westward towards Linden, in Marengo county, and eastwards in Dallas and Wilcox. This difference in the color depending upon the degree of oxidation of certain constituents of the strata, especially the iron-bearing materials, has not unfrequently been observed in the strata, both of the Cretaceous and of the Tertiary age. One of the most striking instances of this sort is to be seen at Prairie Bluff, where the sands forming the lower part of the Bluff exhibit a dark blue, almost black color near the water's edge, while the same stratum is seen to be a white sand where it outcrops at the top of the bluff higher up the river.

Second. Calcareous beds some twenty feet in thickness, holding great numbers of Cretaceous fossils, some well preserved, others only in casts, which in every case appear to be very strongly phosphatic. One of the layers of this section is a sandy limestone containing a large percentage of phosphoric acid (see details below.) These beds appear in a small bluff at the mouth of Tear-Up Creek, above Bridgeport, which has been studied by Mr. Johnson; also in localities recently examined by Mr. Langdon and myself, viz, in bluff at the old Canton landing; on Foster's Creek, in Gee's

Bend; near Snow Hill, Wilcox County, and Minter, Carlowville, and Richmond, in Dallas County; the four last named localities were also visited by Mr. Johnson in 1883.

Third. From sixty to one hundred feet of sand, with indurated bands of calcareous sand passing through it. These hard, projecting, sandy layers are usually filled with the shells of large *Exogyra costata* Say and *Gryphæa vesicularis*, Lam. The thickness of these sandy beds, which apparently immediately overlie the Rotten Limestone, has not yet been accurately determined, but we see some fifty feet or more of them at Prairie Bluff.

Prof. A. Winchell* considers the rock at the base of Prairie Bluff as the topmost of the Rotten Limestone formation, and if this supposition be correct we have the complete section of the Ripley formation. We were, however, unable to satisfy ourselves of the identity of any of the rocks at Prairie Bluff with the Rotten Limestone, though we are convinced that the top of the latter formation does not lie far below the lowermost of the Prairie Bluff strata, since Rotten Limestone appears in the hills near the river a short distance above Prairie Bluff.

SECTIONS OF THE RIPLEY FORMATION.

In the subjoined sections and in the figures on Plate XXVI we have given in detail the characters of the strata making up these subdivisions of the Ripley formation. These sections are given in descending order, that is, beginning with that one which shows the uppermost of the strata, and in the figures of Plate XXVI the equivalence of the several sections is indicated as nearly as it can be made out. In most cases the equivalence is very clearly seen.

Near Palmer's Mill, on Pine Barren Creek, in the eastern part of Wilcox County, Mr. Johnson in 1883 obtained the following satisfactory section showing the actual contact of

*Proc. Am. Adv. Sci., Vol. X, Part II, p. 91, 1856.

Tertiary and Cretaceous strata. The locality was also visited by myself in 1885, as mentioned above.

(*a*) *Pine Barren section.* (*Plate XXV, Fig. 1, and Plate XXVI, Fig. 1.*)

1. Hard, grayish white limestone, characterized by great numbers of a large *Nautilus* (*Enclimatoceras Ulrichi* White), and hence designated by us as the "Nautilus Rock".....10 feet.
2. Calcareous sands forming the basis of the sandy prairies of the vicinity..... 6 feet.
3. Hard, yellowish white, crystalline, sandy in places and filled with red specks. Highly fossiliferous, a *Turritella*, closely related to *T. Mortoni*, being the chief fossil, along with a *Cardita* two or three species of coral, and numerous oysters. This is one of the most persistent of the lower Tertiary rocks towards the eastern part of the State.....55 feet.
4. Yellowish, micaceous sands, with Cretaceous fossils..... 4 feet
5. Bluish gray, calcareous sands, with one or two very prominent hard ledges 4 feet apart, an dtwo or three smaller ledges of similar character. Thickness seen at Palmer's Mill.....15 feet.

In this section the lowest Tertiary bed is No. 3 and the uppermost Cretaceous No. 4, as is very clearly shown by the included fossils of each, and as the two are in direct contact there can be no question of their relations.

Bridgeport.—On the way from Camden to Bridgeport the road descends a long clay hill, in which the clays of the Black Bluff horizon form the surface, (see Pine Barren section, under the Tertiary, Plate XXV). At the foot of the hill is the yellowish white, crystalline limestone, No. 3 of the preceding section, and below that yellow, micaceous sands to the landing. At the Bridgeport Landing these yellow sands form the upper part of the bluff, though their whole thickness is not seen in the immediate bluff of the river, but may be seen at the base of the hills immediately back of the river bluff.

The section at Bridgeport is as follows:

(*b*) *Section at Bridgeport Bluff, Alabama River.* (*Plate XXVI, Fig. 2.*)

1. Yellowish, clayey sands, probably reworked.....10 feet.
2. Coarse, yellow sands.....10 feet.
3. Laminated, gray clays..... 1 foot.
4. Projecting ledge of sandy clay of dark gray color..... 1 foot.
5. Dark gray, nearly black, sandy, and in some parts micaceous clays, in beds about 3 feet thick, separated by hard projecting ledges of sandier material and of lighter color and averaging 8 to 10 inches in thickness .....22 feet.
6. Projecting ledge of light colored, sandy material, forming a pretty firm sandstone. This ledge breaks off in cuboidal blocks, which roll down and cover the slope below it.....18 inches.
7. Dark gray clays..... .3 feet.
8. Projecting sandy ledge.....1 foot.
9. Dark, sandy clays, with two or more harder ledges, down to the water level.....10 feet.

The ledge No. 6 makes a very prominent mark along the face of the bluff, as it is more persistent, harder, and more rock-like than the others. No distinct and well defined fossils were found at this place in the micaceous clays, but in one or two of the harder ledges below No. 6 were found a few friable shells of Ostrea, one *Pecten quinquecostatus* Sow., and a few indistinct impressions of other forms, two of which, if Mr. Johnson is not mistaken as to their characteristics, he was enabled at Eufaula to identify as *Nautilus Dekayi* Mort. and *Placuna scabra* Mort.

Canton Landing.—A short distance below Bridgeport there is an exposure of Cretaceous rocks at the old Canton Landing and in the hill which comes down nearly to the river bluff at that place. This locality was examined by Mr Langdon and myself in the summer of 1855. It presents the following:

(*c*) *Section at the old Canton Landing, Alabama River.* (*Plate XXVI, Fig. 3.*)

1. Yellowish, gray, calcareous, clayey sands in beds 3 to 5 feet thick, separated by harder projecting ledges of somewhat sandier material averaging perhaps a foot in thickness.....100 feet.

The hard ledges named have a tendency to flake off on weathering into sheets as wide as the hand. They often also break off into fragments which are of very irregular shape and of rough surface. All these beds make up the hill, appearing at intervals through the overlying debris, but no continuous section is exposed. In some places the clayey sands lying immediately below one of the hard ledges have the bluish black color which characterizes the whole of the lower part of the Bridgeport bluff, with which there seems to be very little doubt that these are identical.

2. Yellowish, calcareous, sandy clays like the preceding, with a hard, sandier ledge above and below, making top of immediate bluff of the river.....10 feet.
3. Bluish, micaceous clays, the counterpart of those at Bridgeport, with two or more indurated ledges.....12 feet.
4. Light gray, calcareous sands, with an indurated ledge of nearly pure sandstone at the base. The upper part of this bed is disposed to form rough, indurated masses holding phosphatized shell casts and phosphatic nodules.....6 feet.
5. Bluish gray, sandy clays, much more clayey than the preceding bed, about 5 feet in thickness, passing below into a more sandy bed 3 feet thick, containing numerous shell casts and nodules.....8 feet.
6. Bluish argillaceous limestone, containing great numbers of *Exogyra costata* Say, *Gryphæa vesicularis* Lam., and phosphatized shell casts.....3 feet.
7. Bluish, calcareous sands containing many well preserved shells, prominent among which is a *Spondylus*, *Pecten quinquecostatus* Sow., together with phosphatized casts of *Nautilus Dekayi* Mort., turreted shells, &c. This bed goes down to water level....3 feet.

At this bluff there is a very distinctly defined fault, where some fifty yards of the face of the bluff have slipped down a distance of five or six feet. The lines of fault on each side of this piece are marked by broken fragments of the beds or so-called "fault rock."*

In this section, beds Nos. 2 and 3 are entirely similar in mineral composition and appearance to part of the Bridgeport bluff, and the overlying beds are also similar in composition, though of much lighter yellowish color, which is in

* See Fig. 1 below under 'Undulations and Displacements in the Cretaceous Strata."

all probability due to their greater degree of exposure to the oxidizing action of the weather. This bluff is only a mile or so distant across the strike of the rocks from Bridgeport, and there seems to be no reason for doubting that the bluish, micaceous clays and sands of Bridgeport are identical with the yellowish, sandy clays with indurated ledges which form the upper members of the Canton section. The beds numbered from 4 down we consider the same as those appearing at the top of the bluff at Prairie Bluff, to be presently described.

Foster's Creek.—The beds above described at Canton landing continue across the bend lying to the east and known as Gee's Bend, where they may be seen in the banks of Foster's Creek, on John H. Pettway's land.

(*d*) *Section on Foster's Creek.* (*Plate XXVI, Fig. 4.*)

1. Yellowish, calcareous, clay soil supporting a vegetation almost exclusively of cedars.
2. Dark gray, sandy, micaceous clays like those at Bridgeport landing, in beds of 5 to 6 feet thickness, separated by harder ledges of lighter colored and sandier material.....30 feet.
   In the lower part of these beds were collected by myself some of the small Gryphæas, probably *Gryphæa vomer* Mort., first seen by us at Moscow, on the Tombigbee river.
3. Cream colored, impure limestone, glauconitic, holding some phosphatized shell casts.....5 feet.
4. Ledge of coarse grained, calcareous sandstone.....2 feet.
5. Bluish, clayey limestone, no fossils at the top, but filled in its lower parts with fossils which are in many instances only the phosphatized casts of the shell. Among the forms collected here we have identified the following: A *Spondylus*, same as that at Canton; *Gryphæa vesicularis*, Lam., *Exogyra costata* Say, *Scaphites Conradi* Mort., *Nautilus Dekayi* Mort., &c..... 20 feet.
6. Dark brown, crystalline, phosphatic limestone.....1 foot.
7. Yellowish white limestone down to water.....1 foot.

In another part of the plantation, on what is called Livingston Hill, the phosphatic limestone and accompanying rocks may again be seen. From the geographical position of the beds represented in the above section, there is every

reason to think that they underlie the visible portion of the bluff at Bridgeport. The identity of the lower 20 feet or so of this and of the Canton section is sufficiently clear.

Tear Up Creek.—A few miles above Bridgeport, at the mouth of Tear Up Creek, Mr. Johnson obtained in 1883 a good section of the beds underlying those of the Bridgeport bluff, and was able to trace the connection between the two.

(*e*) *Section at the mouth of Tear Up Creek.* (*Plate XXVI, Fig. 5.*)

1. Ferruginous, sandy marl full of Cretaceous fossils.....3 feet.
2. Very firm, white limestone, no fossils seen.....6 feet.
3. Firm limestone, with a few fossils.....2 feet.
4. Sandy, calcareous beds, with fine *Ammonites*.....4 feet.
5. Sandy, indurated limestone forming a broad ledge ....1 to 2 feet.
6. Argillaceous limestone, with *Exogyra costata*, &c.....8 feet.

The fossils of this bluff are plainly Cretaceous and resemble the finest of those occurring at Prairie Bluff. There is good reason for thinking that most of the fine specimens of the old Tuomey collection labeled "Bridgeport" have come from this locality (L. C. J.) The dark, micaceous clays of Bridgeport are easily recognized in the bed of Tear Up Creek between its mouth and its source under McNeill Mountain, as shown in Plate XXVI, Fig. 5. As has already been pointed out, they are seen also in the banks of Pine Barren Creek, at Palmer's Mill. The fossiliferous portion of this bluff is undoubtedly equivalent to the fossiliferous beds occurring on Foster's Creek and at Canton Landing, above described, as also to those at the top of the Prairie Bluff, given below.

During the summer of 1886 Mr. Langdon and myself went in a skiff from Bridgeport to Prairie Bluff and saw no Rotten Limestone in any of the river bluffs, all these exposures representing the Bridgeport and Prairie Bluff strata only.

The principal exposures are the following: From Bridge-

port the bluff extends about a mile down the river, and then after a barren stretch of two miles or more come the bluffs at the old Canton Landing described above, and below that the following:

(*f*) *Section four or five miles below the old Canton Landing, Alabama River.*

1. Sandstone ledge, fossiliferous, yellowish, and wearing into very irregular shapes.....1 to 1½ feet.
2. Highly fossiliferous, blue sand, becoming light gray below containing *Exogyra costata, Turritella*, &c., very much resembling specimens from Eufaula .....5 to 6 feet.

Two hundred yards down the river other underlying beds are to be seen, as follows:

3. Sandstone ledge.....1 to 1½ feet.
4. Light colored sands, no fossils observed .....20 feet.

At an old abandoned landing just above Mixon's we get a very good section, as follows:

(*g*) *Section near Mixon's.*

1. Yellow sands making top of the bluff back of the immediate river bank, at least 30 feet exposed, but apparently forming the whole slope of 60 feet..... 60 feet.
2. Blue, micaceous sands, with the same fossils as No. 2 of the preceding section.....6 to 8 feet.
3. Sandstone ledge .....1 to 1^3_4 feet.
4. Light colored sands .....40 feet.
5. Hard, sandstone ledge .....1 foot.
6. Blue, micaceous, sandy clays (few fossils) .....10 feet.

A mile or two above Prairie Bluff there is a high bluff very much resembling that at the former locality. The strata are undulating, at the lower end of the bluff dipping down stream at the rate of 1 foot in 10, at the upper and lying nearly horizontal. The beds here are as follows:

(*h*) *Section one mile above Prairie Bluff (Rocky Bluff), Alabama River.*

1. In the cliff just back of the immediate bluff of the river there are about 40 feet of strata, light colored, calcareous sands, with indurated bands, as at Prairie Bluff.....40 feet.

2. Dark blue, sandy, micaceous clays, with a few fossils, chiefly Anomias.....20 feet.
3. Hard, yellow, sandy ledge, the broken pieces of which cover the slope of No. 4. It dips below water at the lower end of the bluff.....1 foot.
4. Grayish, fossiliferous sands, full of shells of *Pecten quinquecostatus*, which, however, are very friable .....8 feet.
5. Hard, yellowish, sandy ledge like No. 3.....1 foot.
6. Bluish gray, calcareous sands, with some fossils.....10 feet.

In all these bluffs the indurated sandstone ledges are of very irregular thickness and lateral extent and are probably only local deposits in the regular strata or indurations of the sands.

Prairie Bluff.—This locality has been visited by Professor Tuomey, Professor Winchell, and others.* We have very little to add to their descriptions, except to point out the probable equivalences of the beds occurring here with those just described. The bluff shows the following:

(*i*) *Section at Prairie Bluff, Alabama River.* (*Plate XXVI; Fig.* 6.)

1. Bluish limestone containing *Exogyra costata*, *Gryphæa vesicularis*, and great numbers of shell casts, which are mostly phosphatized. This limestone has two hard ledges passing through it. Professor Winchell gives 6 feet as the thickness of this limestone, but we include with it some overlying fossiliferous, sandy beds and make the thickness..... 20 feet

   Among the forms recognized in casts or otherwise from this stratum may be mentioned *Gryphæa convexa*, *Placuna scabra*, *Scaphites Conradi*, and *Nautilus Dekayi*. Besides there are very many other turreted shells not fully identified. The association is the same as at Canton Landing, Foster's Creek, Tear Up Creek, &c.
2. Sandy beds, with bands of hardened sand passing through them; these harder ledges are usually fossiliferous, the commonest forms being *Exogyra costata* and *Gryphæa vesicularis*. These sands form all the lower part of the bluff..... 50 to 60 feet.

The upper sandy beds contain great numbers of *Ostrea falcata* Mort. The lower beds are of dark blue color, but

*Described in First Bien. Rep. Geol. of Ala., 1850, and Proc. Amer. Assoc. Adv. Sci., Vol. X, Part II, p. 90, 1856.

they bleach out to nearly white sand where they come to the top of the bluff, a short distance up the river from the landing.

The dip of the strata at Prairie Bluff is very considerable, being as high as 300 to 350 feet to the mile.

In the summer of 1886 Mr. Langdon gave this bluff a closer examination. He subdivides that part of No. 1, immediately above the sands, as follows:

1. Shaly, calcareous sands, yellowish gray on weathered surface; contains a seam of phosphatic greensand at the top, immediately underneath the warehouse.....4 feet.
2. Pseudo-Rotten Limestone, i. e., calcareous clay.....3 feet.
3. Shell conglomerate.....3 to 4 feet.
4. Light colored sands &c , No. 2 of the section in the text above.

Mr. Langdon makes the additional important observation here that the very rapid dip down stream is confined to the sanda strata No. 4, and is not shared by Nos. 1 and 3, which half a mile below the warehouse are only about ten feet nearer water level than at the warehouse, while the uppermost indurated ledge in the sands No. 4 dips below the water within a distance of 100 yards, a descent of some 40 or 50 feet. This observation would show an uncomformity between the calcareous and the sandy parts of the strata at Prairie Bluff.

Our discovery of the phospatic greensand here fixes its position in the geological scale. The bed at Coatopa, in Sumter county, seems to have a similar position, but it appears now probable that there are at least two of these phosphatic greensands in the Ripley formation.

Between Prairie Bluff and Rehoboth the hills are formed of the strata overlying the limestone No. 1 of the section. These are yellowish, micaceous sands, in beds 5 to 6 feet in thickness, separated by sandy ledges, and in all respects similar to the upper 100 feet of the section at the old Canton Landing. In structure and general appearance they are like the dark colored, sandy clays of Bridgeport, but the color is much lighter, due, as we believe, to the more com-

plete oxidation of the materials. In these sands there are, in some localities, great numbers of irregular calcareous concretions. All the shell casts occurring in the upper calcareous part of Prairie Bluff, together with the calcareous sandstone which is included in the limestone, are very strongly phosphatic, as has been shown by the recent investigations of the Geological Survey of Alabama.

In the foregoing sections the calcareous and fossiliferous parts, about 20 feet in thickness, appearing at the mouth of Tear Up Creek, on Foster's Creek, at the base of the Canton Bluff, and at the top of Prairie Bluff are, we think, the same; for, though there seem to be slight differences in the succession of the different materials which constitute these beds, these differences are in many cases due to differences in the groupings. The general impression made upon the mind in inspecting them is that they are identical; they contain the same fossils and in the same state of preservation; they hold strata of sandy limestone, or, rather, of calcareous sandstone which are very highly phosphatic; in some instances, where analyses have been made, they hold from 10 to 15 per cent. of phosphoric acid. In all cases they are overlaid by micaceous, clayey sands, traversed by indurated bands of similar, but rather more sandy, material. These overlying beds differ sometimes conspicuously in color, which at Bridgeport, near the water level, is a dark blue, while on the hills back of the old Canton Landing and back of Prairie Bluff the color is a yellowish gray. This difference can be accounted for by differences in degree of oxidation, for where the color at the surface is yellow we have noticed that upon digging into the beds a few inches the dark color may be seen in most cases. In our minds there is no doubt of these equivalences. Prof. A. Winchell is of opinion that the lower beds of the Prairie Bluff section belong to the Rotten Limestone, but we were unable to discover anything there which we could identify with the Rotten Limestone. There is no doubt, however, for reasons above

given, that the Rotten Limestone is not far below the lowest of the Prairie Bluff sands.

Moscow.—On the Tombigbee River we have seen only one locality where the strata of this division of the Cretaceous appear, and that is at Moscow, a mile or two above Black Bluff, already described.

(*j*) *Section exposed at Moscow and below, Tombigbee River.* (*Plate XXVI, Fig. 7.*)

1. Black, shaly clay, devoid of fossils, but containing a few rounded, concretionary masses like fucoids. This stratum appears below the Moscow Landing and is the principal stratum at the mouth of Sucarnochee River. Thin layers of calcite lie upon this clay, having been weathered out from between the layers of clay, in all.....6 to 8 feet.
2. Dark blue, shaly, argillaceous limestone, with thin, projecting ledges of harder material, 10 to 12 feet thick near Moscow, but down the river thickening up to.....20 or 30 feet.
3. Thin ledge made up almost entirely of the shells of the small Gryphæa (*Gryphæa vomer*), noticed also at Foster's Creek, in Gee's Bend.....8 to 12 inches.
4. Hard, white, argillaceous limestone, with *Exogyra costata*, *Gryphæa vesicularis* &c.....10 feet.*

This stratum is indurated near the top, forming a hard ledge which is highly fossiliferous, containing Exogyra, Gryphæa, *Nautilus Dekayi*, Baculites, and univalve shells in phosphatized casts. Many of these casts are covered with little lumps of reddish, phosphatic, clayey material, which has replaced the whole of the original matter of the shells. Casts of this kind have been noticed in the strata of this horizon all across the State to Barbour county end seem to be quite characteristic.

In this argillaceous limestone there is, near the top, a very irregular, hard ledge, consisting in the main of comminuted shells embedded in a sandy matrix. This ledge is very variable in thickness, ranging from a mere line up to 10 feet, and is not conformable with the rest of the strata, but appears to form irregular concretionary or segregative masses

*Near the landing this bed is not less than 25 feet.—E. A. S.

in the limestone. It contains a considerable percentage of phosphoric acid. A similar phosphatic sandy bed appears at top of Prairie Bluff, at the base of the Canton Bluff, and in the bank of Foster's Creek, above described.

The dip of the strata at Moscow is very rapid down the stream, and at the same time irregular, being in places as much as 350 feet to the mile, in which respect it agrees with the dip at Prairie Bluff. It is to be remarked that the dip of the Tertiary beds nearest to these two sections, viz., at Black Bluff on the Tombigbee and at Midway and at Matthews's Landing on the Alabama, is very much less, being only about thirty to thirty-five feet to the mile. The dip of the Ripley beds, indeed, especially near the top, seems to be considerably greater than that of the underlying Rotten Limestone and other Cretaceous strata.

In the summer of 1886 Mr. Langdon and myself made a more careful examination of the bluffs between Moscow and the cut-off, just above the mouth of Sucarnochee Creek, a distance of a mile or two. We found the strata not only strongly undulating, but in six or eight places very distinctly faulted, with a displacement of perhaps ten feet maximum.

Good photographs were obtained of two of these faults, and diagrams were made of several others. A very careful measurement of the thicknesses of the several strata exposed here confirms the estimates above given in the Moscow section, except that the black clays may be a little thicker, and the white, argillaceous limestone, No. 4, is at least 25 feet thick at the landing. Our former measurement was made a short distance below, where only 10 feet of it were seen.

The pockets of cross-bedded sandstone which are noted as occurring at irregular intervals in this limestone are of very limited extent and of varying thickness. In one or two instances they have been broken by the faults above noted. (See Plate XVIII below, under "Undulations and Displacements in the Cretaceous.")

That which we find most difficult of explanation at Mos-

cow is the passage from the undoubted Ripley limestone, which appears to be the same in horizon with the beds at the old Canton Landing, in Gee's Bend, at the mouth of Tear Up Creek, &c., to the black clays of the Black Bluff section (Tertiary), without any show of the Bridgeport sandy clays and the Nautilus and the Turritella rocks. And as the black clays and the Cretaceous limestone are in actual contact, visible to the eye, we cannot explain the failure of these beds to appear here, by interruptions in the continuity of the river bluffs. It is possible that the black clays may be the representatives of the Bridgeport beds, but it is not probable, for the reason that they are lithologically identical with the clays of Black Bluff, which is hardly more than a mile distant.

For the sake of greater completeness, we give below a few sections obtained in the southern part of Dallas County where the Ripley beds are exposed. These localities have acquired a practical interest from the circumstance that they include a bed of phosphate greensand, which has been used with profit upon the soil as a fertilizer. In addition to this greensand bed, there is also a sandy, phosphatic limestone which may some day be utilized, since it holds a very considerable percentage of phosphoric acid.

Snow Hill to Minter.—The town of Snow Hill occupies the summit of a long ridge, at the southern end of which the Nautilus and the Turritella rocks of the lowermost Tertiary form the surface, while at the northern end of the ridge the underlying yellow sands are the surface materials. Descending this ridge towards the north, one passes over yellowish gray, micaceous sands, alternating with hard, sandy ledges which flake off under the action of the weather. These strata are the same as those exposed on the hillside near the old Canton Landing and on the hill north of Prairie Bluff. Near the residence of Mr. W. S. Purifoy, a mile or so from Snow Hill, we see some fifty or sixty feet of these sands and shales overlying a bed of phosphatic greensand three feet or

more in thickness. The section here exposed is the following:

(*k*) *Section near W. S. Purifoy's, near Snow Hill.*

1. Yellowish, micaceous sands, in beds four or five feet thick, separated by ledges of sandier material, which flakes off in weathering.....50 to 60 feet.
2. Phosphatic greensand, holding concretions of white carbonate of lime and a good deal of soft, white lime.....4 feet. This greensand contains from 1.5 to 2 per cent of phosphoric acid. It lies very favorably at the foot of the hill, and at the level of the cultivated fields, and can be dug and spread upon the land with very little trouble or expense
3. Hard, reddish or yellowish, phosphatic limestone, forming very irregular, concretionary masses.....1 foot.
4. Yellowish, calcareous clays containing great numbers of large *Exogyra costata*, *Gryphæa vesicularis*, &c.....20 feet.
5. Impure, argillaceous limestone, containing numbers of the shells above named.....10 to 15 feet.

This greensand has been tested practically by Mr. Purifoy, and with the most flattering results.

On Col. N. H. R. Dawson's place, adjoining Mr. Purifoy's on the north, the same beds are to be seen, together with some still lower. Below the greensand bed there are some sixty to seventy feet of calcareous, sandy beds with hard ledges, and near the base of the series an impure limestone weathering into calcareous clays, in which are embedded great numbers of *Exogyra costata Gryphæa vesicularis*, and phosphatized shell casts, prominent among which are *Nautilus Dekayi*, and *Scaphites Conradi*. This shell deposit lies about six feet above a bed of hard, silicious, phosphatic limestone or calcareous sandstone, which is the lowest of the strata here exposed.

Carlowville.—At Carlowville there is substantially the same section.

(*l*) *Section at Carlowville, Dallas County.*

1. A bed of phosphatic green sand holding much lime, in small concretions and in soft lumps easily crushed between the fingers.....4 feet or more.

2. A clayey, glauconitic limestone, which has been quarried for the purpose of building culverts on the railroad.....8 feet.
3. Yellow calcareous, sandy shales with hard sandy ledges. The color of this material, where wet and not exposed to the weather, is dark blue like that at Bridgeport .....60 feet.
   In the lower part of this there is an impure, argillaceous limestone which holds a great number of the two shells above named, together with casts (phosphatized) of others.
4. Hard, coarse grained, silicious limestone or calcareous sandstone.....2 feet.

Richmond.—A few miles southwest of Richmond, on the land of Dr. G. W. Kyser, we get a more complete section embracing beds which overlie the preceding, viz:

(*m*) *Section 3 miles Southwest of Richmond, Dallas County.*

1. Sandy shales, hardening into a shaly sandstone, forming a conspicuous ledge along the hillsides. This is underlaid by about 20 feet of calcareous sandy clays, similar to those near old Canton Landing..... 20 feet.
2. Calcareous, sandy ledge somewhat like the preceding, but perhaps more calcareous. This also overlies a series of calcareous shales, 85 feet or more.....40 feet.
3. Bed of phosphatic greensand, with lumps of soft white limestone and concretions of lime..... 4 feet.
4. Impure, clayey, glauconitic limestone, making a shelf or ledge around the hillsides.....3 to 5 feet.
5. Calcareous shales interstratified with beds of sandier material which form projecting ledges. These beds correspond in appearance to those forming the hill back of old Canton Landing, and where less exposed to the weather they still retain the dark blue color which is characteristic of them at Bridgeport. They hold the usual fossils in their lower strata, and in weathering give rise to the formation of a calcareous, clayey soil.....60 to 70 feet.
6. Hard, silicious limestone, coarse grained and phosphatic, appearing near the water level at base of the hills.....3 feet.

We have not yet given these localities the close examination which would enable us to say with certainty what their equivalents are; yet, from the position of the fossiliferous, impure limestone containing *Exogyra costata*, *Gryphœa vesicularis*, and the phosphatic shell casts above named, it seems quite probable that this greensand lies some 50 feet

or more above the fossiliferous beds of old Canton Landing and of Prairie Bluff. I should also add that, below the phosphatic, silicious rock at the base of the preceeding sections, we have seen at other localities a yellow sand which is traversed by bands of silicious sandstone precisely as is the case at Prairie Bluff, so that we have very little doubt of the equivalence, although it is not certainly made out.*

These Upper Cretaceous rocks belonging to the Ripley formation have recently acquired a new interest from the circumstance that they are throughout the State very generally impregnated with phosphoric acid, often to such a degree as to render them available as materials for the manufacture of fertilizers. Thus the rock at Moscow and westward to Coatopa and Livingston and thence traced to Shuqualak, Miss., by Mr. Johnson, has been found to be phosphatic, and the same is true of the hard ledges of limestone rock occurring in the Canton bend, and thence eastward to Minter, and on to Fort Deposit, and thence to Chunnenugga Ridge and Union Springs. The occurrence and the characters of these phosphatic rocks will be more fully described at another place.

THE RIPLEY EAST OF THE ALABAMA RIVER REGION.

Mr. Langdon's notes on this part of the State will be found in his article below, and to this the reader is referred. It will be seen that the main variation from the western Alabama type consists in the very great increase in the area occupied by the strata of the Ripley type in the eastern part of the state. Whether this results in part from an increase in the thickness of the strata themselves or from undulations in them, may not perhaps be definitely asserted, but taken in connection with the apparent absence of all the strata that can be referred to the Rotten Limestone, it

*A bed of phosphatic greensand was discovered in 1886 by Mr. Langdon and myself at Prairie Bluff just overlying the limestone strata. Whether this is the same as the bed above described or a different one, we are not yet prepared to say.—E. A. S.

seems most probable that there is actually much greater thickness of the rocks of the Ripley type along the Chattahoochee and its vicinity than further west, and that the Rotten Limestone is replaced or represented by strata of the physical aspect of the Ripley. The paleontology of these two divisions of the Cretaceous has not been very well worked out, so that the shells give us comparatively little help in the matter, especially when we consider the fact that in the Rotten Limestone, although it has a large number of shells in its strata, these shells are of very few kinds and mostly of those kinds that are common in the Ripley strata also.

The Ripley strata as exposed in Russell, Barbour and Bullock counties are made of gray micaceous sands with indurated ledges running through them. In the lower part of the formation we find in Russell and Bullock counties, beds of massive clays, often filled with concretions of carbonate of lime. These clays form the basis of soils that are heavy and to some extent similar to the prairie clays of the Rotten Limestone, except that the color is quite different, being yellowish or reddish instead of black. Lands based upon these clays are known as "hog-wallow" lands. In the upper part of the formation as shown along the banks of the Chattahoochee river a sandy limestone or perhaps better a calcareous sandstone with a great number of echinoderms is conspicuous. This stratum, which forms the river banks not far above Otho, is similar to what may be seen further west between Linden and Dayton and nearer the last named place.

2. The Selma Chalk or Rotten Limestone.

The next subdivision of the Cretaceous group, viz: the Selma Chalk or Rotten Limestone, extends for many miles along both the rivers, and, assuming a uniform dip of 25 to 30 feet to the mile, its thickness cannot be much less than 930 to 1,200 feet. The rock is of comparatively uniform composition, being a gray to bluish colored, argilla-

ceous limestone, traversed at intervals by beds of purer limestone which is at the same time a little harder in texture. In some places the material is a dark bluish clay marl, in appearance not altogether unlike some of the blue or black clays at the base of the Tertiary group. The fossils of the Rotten Limestone are principally Exogyra, Gryphæa and Ostræa, but in the upper and lower parts other forms become more abundant, forming transitions to the overlying and underlying subdivisions.

General Section.—The best general view of the strata of the Rotten Limestone is afforded by the record of a boring for an artesian well at Livingston, Sumter county. The town is situated on the line of the junction of the Rotten Limestone and Ripley formations, and the boring therefore, passes through the whole of the former into the underlying Eutaw green sands. The boring was made from December, 1854, to March, 1857, and the record was carefully kept by Dr. R. D. Webb. The thickness of Rotten Limestone proper penetrated by this boring is 930 feet, the underlying sands and greensands belonging probably, for the most part to the next subdivision. The uppermost 20 feet are certainly in part Lafayette and probably in part Ripley formation, though there are no fossils to decide the matter definitely.

Section of the Rotten Limestone at Livingston, Sumter County. (See Plate XXVIII, Column 4.)

	Materials.	Depth in feet.
1.	Sandy loam, 1 foot	1
2.	Coarse, dry sand, stratified, 12 feet	13
3.	White quicksand (had to be curbed), 7 feet	20
4.	Soft, rotten, blue limestone, thickly set with shells and containing iron pyrites, 180 feet	200
5.	White limestone, harder than the preceeding, with very few if any shells or pyrites, 50 feet	250
6.	Hard, blue limestone, so hard that the auger cuts it with difficulty, clear of shells and pyrites, 7 feet	257
7.	Bluish white limestone, not so hard as the preceding, clear of shells and pyrites, 68 feet	325

8.	Very hard, white limestone, 55 feet At 330 feet, passed through a stratum of oyster shells from which a specimen very much resembling an egg was brought up.	380
9.	Light blue limestone, not so hard as No. 8, but harder than No. 4, 47 feet	427
10.	Bluish brown rock, filled with small shells. In this there was more sand than in the blue or white varieties of rock, 58 feet	485
11.	Hard, white rock, 105 feet	590
12.	Soft, reddish brown rock, 2 feet	592
13.	Soft rock of deep blue color, 20 feet	612
14.	Brownish blue rock, moderately soft, 78 feet	690
15.	Hard, gritty, bluish colored rock, so hard that it had to be drilled, 6 or 8 inches	690
16.	Dark bluish colored rock, easily cut by auger, 10 feet	700
17.	Soft, whitish limestone, with occasional slight change in hardness and color, 250 feet	950
18.	Hard sandstone, 6 feet	956
19.	Sand, in which, at 964 feet, a small stream of water was reached, which ran feebly from the top of the well, 10 feet	966
20.	Sand rock, 1 foot	967
21.	Coarse greensand, in which a larger stream of water was reached at 1,005 feet depth, 38 feet	1,005
22.	Sandstone, 2 feet	1,007
23.	Greensand, 25 feet	1,032
24.	Sandstone, 2 feet	1,034
25.	Coarse greensand, 18 feet	1,052
26.	Flint rock (crystallized), 1 foot	1,053
27.	Very fine greensand, 9 feet In this greensand the well was stopped at a depth of 1,062 feet	1,062

In the following notes are given the characters of the Rotten Limestone as shown in a few prominent bluffs along the rivers, without any attempt to fix absolutely their position in the vertical scale of the boring.

The great degree of uniformity in the lithological characters and fossil contents of the different parts of the Rotten Limestone makes it impossible as yet to give the precise place in the vertical section of its exposures described below, with the exception of those which include the phosphatic greensands immediately below the limestone proper. We

have, therefore, not attempted to represent the main body of the limestone except in the single plate illustrating the boring at Livingstone; but in Plate XXVII we have given several figures illustrating the contact of the Rotten Limestone with the underlying, sandy beds.

EXPOSURES OF ROTTEN LIMESTONE.

About eight or nine miles above Moscow landing there is at Barton's Bluff an exposure of about sixty feet, consisting of dark bluish, clayey limestone, or perhaps better described, a blue marl, with several harder ledges projecting from the face of the bluff. These ledges hold a good many fossils, the principal forms being *Ostrea larva* in the upper ledges and large Gryphæa and Exogyra in the lower ones. These dark, clayey, limestone bluffs continue up the river to within nine miles of Demopolis. They are probably represented by No. 4 of the boring.

On the Alabama a similar material makes the bluff at Lexington Landing, and it holds also a large number of shells, especially those of Exogyra and other oysters.

At Demopolis the bluff is made of a very compact, light blue or gray limestone, which does not seem to be very highly fossiliferous. A similar limestone makes the bluffs for several miles down the river, nearly to Barton's Bluff, where, as alreadys tated, it is more argillaceous and darker in color.

On the Alabama the counterpart of the Demopolis Bluff may be seen at Elm Bluff and at White Bluff.

The same rocks may also be seen on the Upper Tombigbee River (above the mouth of the Tuscaloosa) at Jones's Bluff, where the railroad bridge crosses the river.

Underlying the Demopolis limestone there is a stratum of undetermined thickness of a tolerably pure limestone of light yellow color, filled with concretionary lumps, cylinders, &c., of clay. When this clay washes out it leaves the limestone perforated in every direction, which circumstance is referred to the name "bored rock." Below Arcola this

bored rock is quite thick, and has bedding planes two or three feet apart, which cause the rock to break up into large cubical blocks.

At Arcola and at Hatch's Bluff, on the Tuscaloosa, the bored rock is near the top of the bluff, and underlying it is softer and crumbling Rotten Limestone of the usual character. The bored rock has sometimes been burned for lime, and its outcrop may be followed westward as far at least as Sherman, in Sumter County. It forms a rocky ridge wherever it comes to the surface.

The limestone underlying the bored rock for many feet is tolerably uniform in composition and resembles that of the Demopolis Bluff, except that it is, if anything, rather more argillaceous and less compact, being rather a white, calcareous clay than a limestone. There is nothing of interest to record at any of the bluffs of the river from Hatch's Bluff up to Wolf's Bluff, just above Cowan's Landing.

Here come in the strata, still better exposed higher up at Erie and at Choctaw Bluff, which form the transition between the Rotten Limestone and the sands of the Eutaw formation, and which probably represent the Tombigbee sand group of Dr. E. W. Hilgard, if this group has its counterpart on the Tuscaloosa river.

Characteristic fossils of this horizon appear to be certain reptilian bones, Mosasaurus, the curious *Radiolites lamellosus*, teeth of sharks, and large palatal teeth (*Ptychodus Mortoni* and others).

The lowermost strata of the Rotten Limestone (calcareous clays) also contain many of these fossils, and in addition to those mentioned, shells of Inoceramus in great numbers and of great size. These shells are of fibrous texture, the thickness of the shell (half an inch or less) forming the length of the fibres. In consequence of this structure they are very fragile and it is impossible to take them out unbroken except by removing a block of the matrix rock with them.

In no localities have I seen them in greater numbers and

of larger size than in the long bluff at Fairfield, on the Tombigbee river, in the southern part of Pickens county, and in the fields back of House Bluff, on the Alabama river, in Autauga county. In the former place they are perfectly preserved, and many of them are more than a foot in diameter.

Near House Bluff they are seen in the old fields, associated with Leiodon bones, sharks' teeth, and phosphatic greensands. In the weathering of rock they break into fragments which, though slightly separated, retain their relative position and preserve the outline of the shell. In many cases these fragments cover a space three feet in diameter, indicating the size of the shell as at least two feet in diameter.

These would probably form the first of the transition beds above mentioned.

On the Alabama river these beds make their appearance above the latitude of Selma at Cunningham's and House Bluffs. Inasmuch as their paleontologic relations have not yet been determined and as they are more closely related in lithologic character to the Eutaw, we have thought it best to combine them with the latter formation in our description. The first five sections in the next division (Eutaw) exhibit the Rotten Limestone in connection with the next underlying beds.

TOPOGRAPHIC AND OTHER CHARACTERS.

The sections of the Rotten Limestone away from the rivers are not very satisfactory except along the minor streams, whose banks are often to the depth of fifteen to twenty feet composed of this rock. This limestone, however, appears at the surface across the greater part of the State, or at least as far eastward as the central parts of Macon and Bullock counties, beyond which we have not been able to trace it. In this region there is a very great uniformity in the topographical and agricultural features of the country underlaid by it as might be expected from the

uniformity in the composition of the strata. This section of the State has been so well described by Prof. Tuomey that we cannot do better than quote from him:

"The surface of the country, underlaid by the Rotten Limestone, is but little diversified; it is, however, occasionally broken into rounded bald knolls, as may be seen between Arcola and Demopolis, and between Livingston and Sumterville. The summits of these hillocks are sometimes ornamented with cedars, but more frequently they are quite bare, or covered with but a scanty vegetation; even where the surface is but slightly undulating, bald spots occur where the naked rock has come up. But the most remarkable feature of this region is the extensive tracts of land covered with a deep, black soil of great depth, and extraordinary fertility, which may be seen in various parts of Sumter, Greene, Marengo, Perry, and Dallas, but more particularly in the 'cane brake.' The surface of these remarkable tracts has barely sufficient inclination to admit of easy drainage, without giving the water force enough to remove the soil, so that, instead of excavating a channel at the bottom of the trough-like depressions where this sort of land occurs, it is absorbed by the soil, or spread over a considerable space, where it loses all transporting power.

"The unbroken surface of this region is due to the homogeneous character of the limestone, which suffers waste equally on this account, over considerable areas; and hence the entire absence of ravines, and other abrupt irregularities. The effects of this feature upon the soil must be obvious; nothing escapes, every particle of organic matter remains on the surface, or is removed but a short distance, to be again deposited. A soil formed under such circumstances, and from such a material as this, rotten limestone, can not fail to possess extraordinary fertility.

"All calcareous soils stand high in relation to the power of both imbibing and retaining moisture; the hygrometric property, or the power of absorbing moisture from the atmosphere is also very considerable in such soils. The

effects of these properties are strikingly illustrated, in the uncleared parts of the cane brake, where one can scarcely satisfy himself that he is not standing on the low grounds of a river; the deep, alluvial-looking soil beneath his feet, the moisture-loving long moss (*Tillandsia usneoides*) above his head, together with an undergrowth of Sabals, Palmettoes, and other natives of damp soils, strengthen the illusion.

"But the traveler who visits this region after a rainy season, will stand in but little need of illustration of the retentive power of prairie soil. Little can he imagine that the smooth road, level as a bowling green, and glistening in the sun from very polish, over which he passes, may, in an incredibly short time, be converted into a mass of clay sufficiently soft to allow his wheels to drop down to the axle, but having a tenacity that no clay ever had.

"Situated, as these lands are, with navigable streams to the right and left, they could not fail to be fully appreciated. They are, consequently, nearly all in cultivation, so that it is difficult to conceive what appearance the country presented, to the early settlers. Considerable tracts were entirely destitute of trees, and covered with tall grass, and a profusion of showy, flowering plants.

"The absence of trees on prairies has excited some speculation, and has been attributed to different agencies.—Among the uncultivated spots of the Cretaceous formation of Alabama, there are spots without trees, but the cause is quite obvious: they are elevated spots, where the soil is washed away by every shower of rain, so that the little organic matter derived from the scanty herbage growing on the spot, disappears in this way, instead of remaining to produce a soil: and it is difficult to conceive of localities more unfavorable to the growth of trees. But in the vicinity of these barren spots, wherever soil has accumulated, trees have taken possession, and it was curious to observe their

gradual encroachment, with the persimmon tree at their head.

"But the absence of trees upon the rich soils of the prairies, is more remarkable, yet it appears to me, not more difficult of explanation. Any cause sufficient to prevent the growth of young trees from the seed will produce, in time, a prairie, no matter what may be the character of the soil. The most probable cause seems to be the annual burnings, practiced by the Indians, to facilitate hunting, and traveling all about; that this was their practice, we have the evidence of those who lived amongst them. The same practice prevails amongst the white inhabitants of the thinly settled parts of the country, for the purpose of removing from woodland and other pastures, the dead vegetable matter of the preceding season; and I have seen pine woods, that have been subjected to this treatment, in a fair way to become prairies. The heavy growth of sedge-grass burned off in spring being quite sufficient to produce heat enough to destroy the young trees, just starting from the seed, and often those of some size. Of course this effect can only follow where the grass and undergrowth is in considerable quantity; and it is for this reason that rich limestone soils are most frequently prairie, than those that are less favored; the luxuriant crop of grass, and other plants, furnish combustible matter sufficient to prevent the usual succession of young trees. But where this cause is removed by the discontinuation of the practice alluded to, trees soon take possession,—but even then, trees having heavy seeds, such as the oak, must spread slowly, unlike the pine, which has seeds furnished with wings, and capable of spreading over considerable areas in a short time."

Throughout this territory there are tracts usually the summits and southern slopes of hills in which the Cretaceous rocks are covered with sands and loams. These are the remnants of a covering which once spread over the whole region but which has in great measure been removed by subsequent denudation. The mingling of these sandy beds

with the calcareous clays and clayey limestones of the Cretaceous has given origin to very characteristic soil varieties which will be more specially treated in an another place.

CHALK IN THE ROTTEN LIMESTONE.

Mr. K. M. Cunningham of Mobile, a well known microscopist, undertook for me the investigation of the characteristic rocks of this formation, and the results of his examination of specimens collected from various points from Montgomery westward, are given in the accompanying article by him. The statement has often been made that the true chalk is absent from the Cretaceous formations of North America, but we have here evidence that it is present in no inconsiderable proportions in Alabama, and Hill has recently shown that it occurs in Arkansas and in Texas, and we may reasonably infer that other states will yield upon closer examination very similar material.*

It may, however, be remarked that the Alabama material is far from being pure chalk, since in most cases it is highly charged with clayey matters, and these chalk bearing beds are interstratified with others which hold great numbers of shells of *exogyra, gryphœa,* and other oysters, which are by no means deep sea forms. Yet from the deepest parts of the Atlantic ocean, forms of foraminifera have been dredged in recent times which are identical with some that occur in the Cretaceous chalk of England.

The following list includes species of foraminifera of the chalk of England and Europe, which are also found in the recent Atlantic deep sea mud or ooze.

Rotalia globulosa	Cristellaria cultrata
" turgida	" rotulata
" perforata	" crepidula

*Prof. Calvin, in his recent address before the Am. Association at Brooklyn, (1894) has called attention to the existence of true chalk among the strata of several of the Western States, Kansas, Nebraska, Iowa, &c. The records of these occurrences, have in some cases been in print for many years, but have been either overlooked or not fully appreciated.

Textularia aciculata
" aspera
" globulosa
" striata
Globigerina bulloides
Nodosaria radicula
" raphanus
Dentalina communis
Verneuilina triquetra
Verneuilina polystropha
Lagena sulcata
" globosa
Polymorphina lactea
" communis
" compressa
" orbignii
Planorbulina lobulata
Pulvinulina micheliana
Spyroplecta biformis
Glandulina lævigata

NOTES ON THE MICRO-GEOLOGY OF ALABAMA —CRETACEOUS.

By K. M. Cunningham.

The Chalk.—The first in economic and scientific importance of the strata of Alabama that presents anything of micropic interest, may be placed that portion of the sedimentary series of rocks, composing the Cretaceous system of Geology, i. e., the Chalk formation, and which is strikingly and widely exhibited in the State of Alabama, in a zone traversing the State in a southeasterly direction, and being very nearly limited to the middle and southerly portions of the State. The "Chalk" of Europe has been for more than a half century, a favorite theme for Geological investigation, and it is with the European chalk areas that casual and general readers of Natural Science are mostly familiar, through the medium of foreign publications. It is therefore with a justifiable pride one enters upon the task of showing that the Chalk formation of Alabama has most of the peculiarities which characterize the British and other European chalks, whether in natural scenic variety or in its internal structure, or mineralogically. The definition of "Chalk" is given in the following phraseology transcribed from the 9th, or latest edition, of the Encyclopædia Britannica: "Chalk, an earthy limestone of the upper Cretaceous group of rocks; it has a specific gravity of from 2.4 to 2.6, is rough to the touch, is friable, and presents an uneven fracture; it has an insipid taste, and adheres slightly to the tongue; it is usually white, and imparts its color to surfaces over which it is rubbed. On microscopical examination, chalk is found to consist in the main of the minute shells of the Foraminifera. In addition to calcium carbonate, chalk usually contains about 5 per cent. of water, with some free silica, and ferric oxide, besides minor impurities." Also, in the Micrographic Dictionary, an explanation of the structure of chalk is given in which it is stated that the microscopic shells are embedded

in an apparently amorphous paste, or matrix, which, when its structure is examined under the highest powers of the microscope, shows the extremely small bodies commonly known as crystalloids, and first described by the micrographer, Dr. Ehrenberg, and found by him to be a material component of the chalk of Brighton and Dover cliffs, on the British coast; these particles have an average diameter of 1.-4000 of an inch, and are likewise characteristic of the chalk of Alabama, and are beautifully demonstrated in specimens of the milky waters, resulting from the brushing down in water of samples of the chalk; when a considerable thickness of this chalk sediment is permitted to dry, its particles cohere, and every touch of the substance examined under a thousand diameters power, is shown to be made up of an aggregation of these infinitesimal oval particles. These particles, together with the foraminifieral forms, give conclusive evidence of chalk, and are peculiar to chalk alone. Having been commissioned, and instructed by the State Geologist for Alabama to take the field and assist him in securing satisfactory proof that there existed a true Chalk formation within the bounds of the State of Alabama, and in determining its approximate extent, the month of March, 1892, was devoted to visiting and noting localities of occurrence at many points within the known Cretaceous area. As a result of the operations and tests in the field, satisfactory proof was secured of the existence of true chalk strata in the area examined. In pursuance of the results to be accomplished, the following points in the Cretaceous area were visited and suitable cabinet specimens of the chalk were secured and forwarded to the State Geologist, at Tuscaloosa, Ala., for permanent preservation. At the same time duplicate specimens were reserved for the final determinative proof to be finished in the laboratory: Livingston, bluff on Sucarnochee Creek; Gainesville, on Tombigbee river; Epes Station. on A. G. S. Ry; Jones' Bluff, on Tombigbee River. All of the above points being situated in Sumter county, Ala. Eutaw, on the A. G. S. Ry; Hays Station, A. G. S. Ry; Choctaw Bluff, on Warrior River. All situated in Greene county, Ala. Arcola Bluff, on Warrior River, in Hale county, Ala.; Marion Junction, on E. T. V. & G. Rd; Selma, and the following points on the Alabama River: Cahaba, King's landing, White Bluff, Elm Bluff, Moseley's landing; all situated in Dallas county, Ala. Bridgeport and Prairie Bluff, on Alabama River, both places situated in Wilcox county, Alabama. Harrison's landing, on Alabama River, in Autauga county, Ala. Benton, on Alabama River, in Lowndes county; Montgomery, on Alabama River, in Montgomery county, Ala. Uniontown, Gallion, and Van Dorn stations, on E. T. V. & G. R. R.; and Demopolis, on Tombigbee River. All of these latter points being in Marengo county, Ala.

The Bluffs present imposing evidence of the great thickness of the Chalk strata, in cases towering above the river level to a hundred

feet or more, and vieing in their impressiveness with the Chalk escarpments characteristic of the chalk scenery of the English coast and its downs. After quitting field investigations, work was resumed on the duplicate specimens, and microscopic slide preparations representative of each locality visited were duly prepared and appropriately labeled, and in addition to the slides so prepared a quantity of the foraminiferal powders was permanently preserved in small vials, each containing from one to two cubic centimetres, and from the contents of these vials a sufficient amount was used to prepare its corresponding slide, both slides and vials were properly labeled and forwarded to the State Geologist for preservation in the State Geological Cabinet. A portion of the prepared material from each point visited was reserved, and the whole mixed together, so as to indicate the average aggregation of specific forms for the whole chalk area. Every portion of this material so mixed was carefully examined, and every form illustrative of a typical species was removed or selected out of the material, and after exhausting all available, distinct specific forms, they are isolated and transferred to two slide preparations and arranged serially in lines, to be used in the identification of the specific names of the foraminiferal shells characteristic of the Alabama Chalk. The identification of the specific forms was successfully undertaken and finished through the courtesy of Prof. Anthony Woodward, Ph. D., of New York, and whose list of specific names appears below at the end of this article. The result of his determinations, shows that the chalk of Alabama is richly represented in the number of its genera and species, as the list enumerates forty-one species under nineteen genera. If close attention is paid to all that has been recorded in the preceeding text, sufficient evidence is adduced, and proof fully established that the Chalk is widely distributed over a goodly portion of the State of Alabama, and the citizens of the State whose agricultural interests, and homes, are situated within the Chalk area, and readers in general have it within their power to form a more correct view of its nature and origin, and they would be wise to abandon the incorrect terms common thereabout, and to substitute the distinctive appellation "Chalk," for "Rotten Limestone," "Soapstone," and "Limerock;" localisms, which are really misnomers, and which are misleading in their persistent use. It may not be inappropriate to give herein for the benefit of those who have but a limited acquaintance with Natural history, an outline of the position occupied by the Foraminifera in the scale of organized nature. The Foraminifera, are classed as a subdivision of the Rhizopoda, of the natural system of classification of animal life, the word is derived from two Greek roots, meaning root, and foot. The Rhizopoda composing organisms of the simplest structure, with soft bodies, or with external shells, or

tests. The word Foraminifera, is derived from two Latin word roots, meaning; hole, and bearer on account of the shells, in a majority of instances, being perforated everywhere with minute holes, or pores, called "foramina," through which are extruded portions of the internal "bioplasmic" or living substance termed "sarcode" and which thread-like extensions are termed "pseudopodia" or false feet; it is by means of the retractile power of this gelatinous-like living substance through the perforations of the shells, that the alimentary and secreting functions are exercised in building up the successive chambers of the shell, and in the reproductive duplication of its kind in the living species. Geology recognizes the prevalence of Foraminifera in the earliest of the sedimentary strata grouped under the system of Rocks, known as the Laurentian, and while there is some existing controvery, as to the true definite character of the structure asserted to be a foraminifer, namely the *Eozoon Canadense*, yet there is no doubt of the plentiful occurrence of the Foraminifera in all epochs or periods subsequent to the depositions of the Laurentian strata, and of their persistence through all geological periods down to the present time.

FORAMINIFERA FOUND IN THE ALABAMA CHALK.

IDENTIFIED BY

ANTHONY WOODWARD, PH. D.

Anomalina ammoides, Reuss, sp.
Bigenerina capreolus, d'Orbigny, sp.
Bolivina dilatata, Reuss.
" punctata, d'Orbigny.
Bulimina elegans, d'Orbigny.
" elongata, d'Orbiney.
Cristellaria, calcar, Linne, sp.
" gibba, d'Oobigny.
" cultrata, Montfort, sp.
" rotulata, Lamarck, sp
Discorbina Berthelotii, d'Orbigny, sp.
Frondicularia alata, d'Orbigny.
" gaultina, Reuss.
" inæqualis, Costa.
" lanceola, Reuss.
" marginata, Reuss.
" solea, (v. Hag.)
Gaudryina pupoides, d'Orbigny.
Globigerina bulloides, d'Orbigny.
Legena hispida, Reuss.
" ovum ? Ehrenberg, sp.
Lingulina carinata, d'Orbigny.
Marginulina Badensis, Hautk.
Nodosaria bacillium, Defrance.
" badensis, d'Orbigny.
" communis, d'Oobigny.
" (D) filiformis, d'Orbigny.
" obliqua, Linne, sp.
" raphanus, Linne, sp.
" (D) retrorsa, Reuss, sp.
" (G1) rotundata, Reuss.
" vertebralis, Batsch, sp.
Pleurostomella alternans, Schwager.
Pulvinulina Canariensis, d'Orbigny, sp.
" lobata, Hautk.
" Menardii, d'Orbigny, sp.
Polymorphina cammuis, d'Orbigny.
Textularia globulosa, Ehrenberg,
" sagittata, Defrance.
Truncatulina lobatula, W. & J. sp.
Vaginulina legumen, Linne, sp.

3. The Eutaw Formation.

GENERAL CHARACTERS.

As noted above, the sandy, fossiliferous strata lying beneath the argillaceous and calcareous rocks whose lithologic character is so well defined by the name of Rotten Limestone are referred by us to the Eutaw formation. In striking contrast with the Rotten Limestone, this series of deposits consists of sands and clays with little or no calcareous matter except in the uppermost 25 or 30 feet spoken of above as forming a transition between the Rotten Limestone proper and the sands of the undoubted Eutaw.

This upper member of the Eutaw formation consists at the summit of a bed 5 feet in thickness of indurated, calcareous sands, with numerous fossils and irregularly shaped nodules of nearly pure phosphate of lime, together with many highly phosphatized shell casts, and in addition the sand itself is very generally phosphatic. Below this bed there are 15 feet of sand with comparatively few fossils, except in a thin layer of compacted shells at the base and in two or three similar shell layers dividing the sand at different horizons. These shell beds are also usually phosphatic. Beneath the lowest comes a bed of greensand 6 to 8 feet in thickness, which is distinguished by its high percentage (up to 5 per cent.) of phosphoric acid. These phosphatic and calcareous beds have been less closely examined on the Alabama River than on the Tombigbee, where they appear to be somewhat thicker.

The bulk of the lower and principal member of the Eutaw formation consists of cross bedded sands, with subordinate beds of pebbles and of thinly laminated clays with sandy partings in many alternations. The exact sequence of these beds is known only for about 80 or 90 feet below the phosphatic strata above mentioned. (See profile at the House Bluff, Alabama River, Pl. XXVII, Fig. 5.)

The most striking peculiarities of the various beds of the lower member of the Eutaw formation are found in the abrupt changes which they undergo in both the vertical and horizontal directions. The dark gray, laminated clays with sandy partings seen at Finch's Ferry, Tuscaloosa River, may also be seen farther up the river at Semple's Bluff and at Brown's Bluff, and with nearly the same characters in all three localities. With this exception, however, I know of none of the Eutaw beds which preserve their characters with anything like uniformity for more than a few rods. Laminated clays pass into cross bedded sands or rather are replaced by them; cross bedded sands thin out abruptly, as if forming lenticular masses; the pebble beds thicken up and thin down rapidly within a few yards' distance; and indeed it is impossible to follow any of the beds with certainty from one end of a long bluff to the other, and it would be well nigh impossible to get two vertical sections of a bluff, 100 yards apart, which would exhibit the same sequence of materials. Two examples will illustrate my meaning. At Stave Bluff, Tuscaloosa River, half a mile long, we see at the upper end and near the center of the bluff a preponderance of laminated clays with thin intervening sheets of cross bedded sands, but at the lower end of the bluff the clays disappear or cease, not, however, by dipping below the water level, but abruptly, and they are replaced by thick beds of yellow sand which neither overlie nor underlie the clays, but are substituted for them on the same horizon. Again, at Merriwether's Landing, further up the river, where the bluff is perhaps half a mile long, at the landing (upper end of the bluff) we find the bluff made up of laminated clays with sand partings, the sand partings becoming thicker and thicker as we descend, and assuming within 10 feet of the water the character of cross-bedded sands with thin clay sheets following some of the lines of false bedding. One hundred yards or less below the landing the whole bluff ap-

pears to be cross-bedded sands with clay seams, including, about twenty feet above the water, a 10 foot bed of sand. These change again, not because of the dipping of the strata below the river level, but because of the replacement at the same horizon of one set of beds by another.

The great mass of the Eutaw formation seems to have been deposited in shallow water by ever varying currents.

The absence of all fossils except an occasional lignitized tree trunk* and the lack of any persistent or easily identified beds of any kind make it impossible for us here to sum up the thickness as we have done in the Tertiary group, and we are therefore compelled to rely either upon width of outcrop across the country of the beds of this formation or upon the borings for artesian wells. The thickness of the beds of this formation, estimated from their outcrop along the banks of the Tuscaloosa River from Finch's Ferry to Big Log Shoals, on an assumed uniform dip of 40 feet to the mile, is about 200 feet; but this estimate is probably too small. Between Big Log Shoals and White's Bluff no Cretaceous rocks are exposed on the river, but they may be seen upon the neighboring hills, and recent observations of Mr. Langdon and myself indicate that this stretch of the river is almost entirely underlaid by the beds of the Eutaw formation; and if this is so their total thickness can hardly be less than 300 feet. This estimate is confirmed by the width of the outcrop of the Eutaw beds upon the hills on both sides of the Tuscaloosa River. On the eastern side, in Hale county, they are found from three miles south of Havana down to Greensborough, and on the western side, in Green county, from just south of Knoxville down to Eutaw, or in each case about 10 miles in a direct line across the strike. This with a uniform dip of 30 feet to the mile would correspond to a thickness of 300 feet, and with a dip of 40 feet per mile to

*At Prattville in Autauga county, and at Broken Arrow Bend on the Chattahoochee, there are strata with a few shells referable to the Eutaw horizon, as shown below.

400 feet; 300 feet may therefore be given as the minimum thickness of these beds along the Tuscaloosa. A boring now in progress at Eutaw reached the purple clays of the Tuscaloosa formation at a depth of 400 feet; which indicates a thickness for the formation nearly the same as that estimated from the width of outcrop and dip. The corresponding portion of the course of the Alabama River—i. e., between Selma and Montgomery—is such that the lowermost members of this formation are not there exposed.

SECTIONS OF THE EUTAW FORMATION.

The following sections illustrate fairly well the lithologic and other peculiarities of the Eutaw formation, including the transitional beds, which may hereafter, upon paleontologic grounds, be classed with the Rotten Limestone.

(a) *Section of the bluff at Erie, Tuscaloosa River. Plate XXVII, Fig. 1.*

1. Rotten Limestone of usual character.....30 feet.
2. Indurated ledge of calcareous sand, containing grains of glauconite, strongly phosphatic and in part filled with oyster shells 5 to 8 feet.
3. Yellowish sands containing shells in the upper part, and thus forming a continuation of the preceding.....8 feet.
4. Projecting hard ledge filled with small bivalve shells, chiefly oysters.....8 to 12 inches.
5. Yellowish sands, with some glauconite, becoming more and more glauconitic as we descend.....5 to 6 feet.
   The lower part of this stratum, say one or two feet, is indurated, shells become more abundant, and there is thus a gradual transition into the next underlying bed. In these sands, which are hollowed out from beneath the preceding ledge, there are embedded some curious stalagmitic formations, of indurated calcareous sand, which stand up like small pillars. These are strongly phosphatic, and have much the appearance and composition of the ledge No. 4.
6. Indurated ledge of sand, greensand, and shells, mostly oysters, like that at Choctaw Bluff.....1 foot.
7. Greensand, cross bedded.....3 to 4 feet.

8. Laminated, blue clay, in several distinct layers, which project from the vertical faces formed by the greensand above and below it.....2 feet.
9. Greensand like No. 7, but with more glauconite to water's edge; contains much phosphoric acid.....1 foot.

Just above Erie there is a great southwestward bend in the river, by reason of which only the Rotten Limestone appears in the river banks, the greensands being all below the water level. This condition of things continues up to McAlpine's Ferry, where we have the following:

(*b*) *Section near McAlpine's Ferry Tuscaloosa River.* (*Plate XXVII, Fig. 2.*)

1 Rotten Limestone of variable thickness, with a covering of Lafayette above it.
2. Calcareous sands, indurated and glauconitic, partly filled with shells, mostly oysters..... .....6 to 8 feet
3. Sands..... .....8 to 10 feet
4. Greensands to water's edge.....6 feet or more

From Eastport, just above McAlpine's Ferry, up to Melton's Bluff the course of the river is nearly along the strike of the strata, and we have practically the same beds as those above described at Erie along this stretch of the river. The undulations which are usually observed along the outcropping edges of our Tertiary and Cretaceous strata may be seen here also.

(*c*) *Section at Melton's Bluff and Eastport, Tuscaloosa River.*

1. Cross bedded sands, grading off below into greensand.....10 feet
2. Greensand, forming a bench or ledge 6 to 8 feet broad and 3 feet thick down to the water's edge.

Between Melton's Bluff and Choctaw Bluff another great southwestward bend in the river causes the greensands to disappear below the water level, to reappear near the last named bluff, where we get the following very interesting section, which, however, embraces practically the same beds with the Erie bluff, the two places being situated from each other in the direction of the strike of the strata.

(*d*) *Section at Choctaw Bluff, Greene County, Tuscaloosa River. (Plate XXVII, Fig. 3.)*

1. Rotten Limestone of the usual appearance, with a cover of Lafayette or second bottom deposits. The rock contains some fossils, Inocerami. and bones of reptiles.....20 feet or more.
2. Indurated, calcareous sands, with some glauconite, filled with shells, mostly *Exogyra*, forming a projecting ledge, which is a very prominent and persisting mark along the face of the bluff*.....6 to 7 feet.
3. Yellowish, cross bedded sands, shading off above into the fossiliferous ledge. These sands become more and more glauconitic and devoid of fossils below..... 15 feet.
4. Indurated ledge of glauconitic sand and small oysters, slightly effervescent, phosphatic .....1 foot.
5. Highly glauconitic sands, strongly phosphatic. These sands show above the water at the upper end of the bluff 6 to 8 feet, but sink below the water at the lower end, making a dip of about 20 feet to the mile along this stretch of the river.

This section shows well the point of contact of the Rotten Limestone with the glauconitic beds below it. The beds immediately under the Rotten Limestone are coarse, calcareous sands, somewhat indurated and filled with the shells of Exogyra, No. 2 above. Both the Rotten Limestone and the ledge are filled with nodular masses of iron pyrites. One mile below this, at Stevens's Bluff, the sands are all below the water, and only the Rotten Limestone above it; the same is true of the banks at Hamlet's Shoals. These beds, as above intimated, have acquired a considerable interest from the fact that most of them are strongly impregnated with phosphoric acid. This seems to be particularly the case with the glauconitic sands, especially when they are indurated; and in many cases the induration seems to be due to the formation of phosphates. Wherever the beds immediately underlying the Rotten Limestone have been examined, from the Mississippi line eastward to Wetumpka, and even farther toward the Georgia line, they have been distin-

*This bed has been called "Concrete Sand" by Prof. A. Winchell, and the next below it, "Loose Sand" (Proceedings Am. Asso. Adv. Sci., Vol. X, Part II, p. 92, 1856). He, however, limits the former name to the first 2 or 3 feet below the Rotten Limestone.

guished by containing very notable quantities of phosphate of lime, either impregnating the greensands in a general way or concentrated into irregularly shaped nodules of nearly pure phosphate of lime. These, should they ever be found in sufficient quantity, will be of great value as an article of export. The phosphatic greensands, without the least doubt, can be very profitably used as fertilizers where they are convenient to transportation. This subject, however, will be more specially treated in another section of this Report.

At Finch's Ferry, near Eutaw, on the Tuscaloosa River, there is a bluff which varies from 50 to 75 feet in height, in which strata underlying the phosphatic sands of Choctaw Bluff are seen. The upper 25 to 40 feet of this bluff (according to locality) consist of yellowish, crossbedded sands, in which a few indistinct fossils have been found, and below this some 25 feet of alternating blue clays and cros beded sands; then, forming base of the bluff, about 20 feet of laminated, blue clays, with partings of sand. No fossils have yet been observed in these lower beds.

(*e*) *Section at Finch's Ferry, Tuscaloosa River.* (*Plate XXVII, Fig 4.*)

1. Yellowish, cross bedded sands, with indurated bands at intervals. This sand contains a few casts of shells, mostly oysters, and pieces of silicified wood.....25 to 40 feet.
2. Laminated blue clays, with partings of sand.....10 feet.
3. Alternations of cross bedded sands and blue, laminated clays .....5 feet.
4. Bluish, glauconitic sands.....10 feet.
5. Laminated, blue clays, the laminæ separated by thin sand partings.....20 feet

The exact position of this section with reference to that at Choctaw Bluff is not certainly made out, but it is quite possible that some of the lowermost of the Choctaw Bluff beds may appear in the highest parts of the bluff at Finch's Ferry. At all events the two sections are very nearly conterminous.

On the Alabama River the same beds are seen at the Batte Smith Bluff, Cunningham's Bluff, and the House Bluff.

At the last-named locality we have perhaps the best section of the transition beds between the Rotten Limestone and the Eutaw formations to be seen in the State.

The bluff, gapped by ravines, forms the northern bank of the river for a mile or more at the top of one of those long bends made by the Alabama in this part of the State. Near the lower western end of the bluff, where these gaps are close together, the sharp crested, interjacent ridges come out to the face of the bluff in cross section like the gable ends of a house, whence the name of the bluff.

The uppermost (i. e., most eastern) of these bluffs has about thirty feet of Rotten Limestone on top, and the washings from this have whitened all the underlying red and yellow sands, so that if not closely examined the white bluff would easily be mistaken for limestone throughout. The next bluff below separated from this by a narrow ravine only, and of nearly the same height, consists of yellow, cross bedded sands to the very top. The absence of the Rotten Limestone on the top of this second bluff and its presence on top of the next succeeding or third bluff are due to undulations in the strata. The contrast between the first two bluffs is very striking. The uppermost bluff is probably the highest of the set and is about one hundred and fifty feet high, and the strata exposed in it are the following:

(*f*) *Section of the House Bluff.* (*Plate XXVII, Fig. 5.*)

1. Rotten Limestone.....20 or 30 feet.
2. Greensand, with phosphatic nodules .....4 feet.
3. Conglomerate of shells embedded in loose sand.....1 foot.
4. Light colored sands, with irregular deposits of shells and a six inch layer of shells at bottom.....5 feet.
5. Sands 8 feet, with a layer of shells at bottom, 1 foot, in all..9 feet.*
6. Alternating beds of horizontally laminated and cross bedded sands, yellow (glauconitic); the separate beds from 1 to 2 feet thick. These beds are marked with numerous streaks deeply colored with iron.....40 to 50 feet.
7. Laminated clays (soapstone), devoid of fossils.....10 feet.
8. Blue, micaceous sands, no fossils.....15 feet.

*Nos. 2 to 5, inclusive, constitute the "Concrete Sand" of Dr. Winchell.

9. Light colored sands, with large, bowlder-like concretions of concentric layers.....20 feet.
10. Alternations of the laminated clays and blue sands above described down to the water level.

The great irregularity in the stratification of the sands of this formation is well exhibited in the House Bluff, where hardly any two sections will show the same sequence of beds. The following section of this bluff was taken by me in the summer of 1886, and shows the stratification of the first quarter of a mile of the bluff rather than that of a single locality:

(g) Section of the Upper part of House Bluff.

1. Rotten Limestone, including near the base a bed of phosphatic greensand four and a half feet in thickness.....30 feet.
2. Ledge of oyster shells embedded in sands, forming a hard ledge.....8 inches.
3. Whitish sands.....8 to 10 feet.
4. Ledge of shells like No. 2.....8 to 11 inches.
5. Yellowish, cross bedded sands, indurating into rounded, bowlder-like masses of concentric structure. On the weathering and caving of the bluff, these bowlders break off and roll down to the water's edge and cover all the slope below them. The two hard ledges of shell conglomerate also break off in a similar way, and their fragrants also cover the slope below .50 or 60 feet.
6. Yellowish, cross bedded sands like the preceding, except that they are traversed by clay bands and partings of every irregular thickness and extent..... 10 feet.
7. Compact sands, making a smooth, perpendicular face.....15 feet.
8. Cross bedded sands, the lower part containing gray clay partings, and in the lowermost 5 feet merging into bluish gray, laminated clays.....15 feet.
9. Blue sands to the water's edge..... .5 feet.

The resemblance between this section and those of Choctaw Bluff and Finch's Ferry, Tuscaloosa River, is sufficiently strong to justify us in correlating them in a general way, though we cannot, of course, expect to find absolute identity in the individual beds.

The two ledges of shell conglomerate appear in the hills in many places westward of this bluff. Between the two

Mulberry creeks, one and a half miles west of Statesville, they are nearly at the general level of the high table lands; and everywhere about seven or eight feet above the upper of these ledges, appears the bed of phosphatic greensand, so well known in the vicinity of Hamburg, Perry county. These beds rise towards the north and appear in several places in Autauga county, high up on the hills. In the vicinity of the old Slaton place and the old Jim Brown place, the shell conglomerate and the greensands are exposed over a large territory.

All the bluffs of the Alabama River, from House Bluff up to Montgomery, show more or less of the House Bluff beds, according to the windings of the river. At Washington Ferry the banks are made of the laminated gray clays with interbedded sands, which are seen near the base of House Bluff. About two hundred yards above the Washington Ferry there is a high red bluff showing the following:

(*h*) *Section of bluff near Washington Ferry, Autauga County.*

1. LaFayette sands and red loam.....10 or 15 feet.
2. Cross bedded, yellow sands, stained deep red by the washings from No. 1.....50 feet.
3. Laminated clays and sands.....50 feet.

No. 2 above corresponds with No. 5 of my House Bluff section, while No. 3 corresponds to the rest of the House Bluff.

The river bluff just below the steamboat landing at Montgomery, shows the following:

(*i*) *Section at Montgomery.*

1. LaFayette beds (very closely resembling what we have called second bottom deposits),.....15 to 20 feet.
2. Laminated, gray sands, with gray clay partings..... ...3 feet.
3. Gray clayey sands, with white and gray clay partings.....4 feet.
4. Rather compact, yellow sands with small, lens-shaped, spherical, and other irregularly shaped masses of pure, gray clay scattered through the mass of sands. These form the greater part of the perpendicular bluff to the river below the drift deposits, and extend to the water's edge.....25 or 30 feet.

In the railroad cuts above this section there are numerous fine exposures of the cross bedded yellow sands of the Eutaw at least fifty feet in thickness.

Also along the Montgomery and Eufaula railroad where it cuts through the Cemetery Hill sections are exposed of these sands extending half a mile or more, and aggregating more than fifty feet vertical thickness.

Where the Rotten Limestone is seen at the summit of the bluff, as at Choctaw Bluff and at House Bluff, the geological horison of the underlying beds of the section is at once determined. The uncertainty is felt only in regard to the exact relative position of the Finch's Ferry beds and those where the Rotten Limestone is absent.

Between Finch's Perry and Big Log Shoals, a distance of four and a quarter miles or a little more, across the strike, which corresponds to a thickness of about one hundred and fifty feet of strata, the banks of the river are composed of laminated, bluish clays and cross bedded, glauconitic sands, in many alternations. Interbedded with these, at two or three points, are thin beds of pebbles, from eight to twelve inches thick, and thin layers of lignitic matter, consisting of lignitized stems, twigs, and other fragments, embedded in bluish sands. In addition to these, lignitized trunks of trees are not infrequently seen at many of the exposures. Occasionally, also, a silicified trunk is to be found lying upon the bluff, but whether derived from the Cretaceous or from the overlying Lafayette deposits is still a matter of doubt.

It has as yet been impossible to ascertain the actual sequence of these different beds for the whole distance mentioned above, but the following detailed sections will probably cover nearly their entire thickness.

Immediately below the laminated clays which form the base of the exposure at Finch's Ferry, come alternations of similar laminated clays, with cross bedded sands many feet

in thickness, which are to be seen at Semple's Bluff, just above the railroad bridge, and at Collin's wood yard, where about ten feet of thickness are to be seen.

Child's Ferry.—At Child's Ferry similar strata are exposed, the bluff being some thirty feet high. The lower part of this exposure consists, without doubt, of the same beds as those at the top of the bluff at Merriwether's Landing given below:

(*j*) *Section at Merriwether Landing, Tuscaloosa River.*

1. Laminated clays and sands; the sands are bluish green in color when freshly exposed, but become yellowish on weathering.....10 to 15 feet.
2. Sands.....7 to 8 feet.
3. Laminated sands and clays again to the water's edge, 20 feet or more.

Much of the blue clay in the lower part of this bluff breaks up on drying into small chips, which are covered with white efflorescence derived from the oxidation of iron pyrites, nodules of which are of common occurrence in the clay. Along the bluff are to be seen many trunks of trees, either lignitized or silicified.

The lowermost five or ten feet of the beds exposed at Merriwether's are seen again at the top of the bluff at Long Bend, where the following section is exposed:

(*k*) *Section at the head of Long Bend, Tuscaloosa River.*

1. Cross bedded sands forming top of bluff.....5 to 10 feet.
2. Laminated, blue clays.....2 to 3 feet.
3. Bed of quartz pebbles.....2 to 3 feet.
4. Laminated, blue clays again, containing galls or concretions of pure, light colored clay .....4 to 5 feet.
5. Coarse grained, yellowish sands, strongly cross bedded, running down to the water level.....5 feet or more.

Hickman's.—At Hickman's, below Big Log Shoals, the bluff is made up of laminated clays alternating with cross bedded sands in the most irregular manner. The thickness of these beds was not estimated, but their relative position is as follows:

or by the lithological characters, carry the distinction between the two upper members of our marine Cretaceous consistently across the state. This is the cause of some embarrassment when we come to represent these divisions on the map, and we have been forced, in the eastern part of the state, where the chalky strata of the Rotten Limestone fail, to color as Ripley an area which is undoubtedly made up of the time equivalents both of Ripley and of Rotten Limestone. Perhaps the better plan would have been to give the name Ripley to all the strata above the Eutaw sands, and distinguish between the clear sea or open sea deposits of chalky nature, and the littoral deposits which we have most commonly had in mind when we have used the term Ripley. As subdivisions of the Ripley, on this plan, we might use the names *Selma Chalk*, and *Cowikee marly sands*, since the Cowikee creeks traverse nearly the whole breadth of this formation where the chalky beds are absent.

An examination of the distribution of the Cretaceous formations in the adjoining states will make the condition of things in Alabama more easily understood, and for this purpose the accompanying sketch map has been prepared, Plate XVI. Of all the Cretaceous formations the Tuscaloosa is the most widely distributed. It continues eastward along the foot hills of the Appalachians to Maryland and beyond. The other divisions have not been traced eastward beyond the western part of Georgia. The map will show how in the upper half of Tennessee the whole Cretaceous, above the Tuscaloosa, is represented by littoral or off-shore deposits, chiefly sandy, in which there are a few fossils of Eutaw species in the eastern or lower part and of Ripley species in the western. In the eastern part of Alabama we have a similar state of things, for along the Chattahoochee River the lower parts of these sandy strata hold Eutaw species and the rest Ripley species, all the strata being of littoral or off-shore character. Below the central line in Tennessee the chalky beds of the Rotten Limestone wedge in between these two sandy series and gradually narrow down or crowd out the

On the Chattahoochee river we find a bluff at Broken Arrow Bend where strata resting directly upon the Tuscaloosa formation contain marine shells, but here also they are of a nature to give us very little if any assistance in determining the exact geological horizon although in general corresponding pretty closely with forms occurring immediately below the Rotten Limestone at Choctaw Bluff on the Warrior River. From the relation to the underlying Tuscaloosa beds we have considered them to be Eutaw strata. The section at the point named is as follows:

(*n.*) *Section at Broken Arrow Bend, Chattahoochee river.*

(1.) Dark gray micaceous sands, with indurated ledges at intervals of 2 or 3 feet. These ledges are quite calcareous and hold many shells of exogyra, etc..... .. 20 ft.
(2.) Cross bedded sands and mottled clays, (Tuscaloosa).... 7 ft.

At other bluffs a short distance further down the river, strata overlying No. 1, of the above section appear, and some of these contain a great number of impressions of shells in a clayey matrix. These shells also appear to be impossible of determination. These instances will serve at least to exhibit the change in the character of the Eutaw formation as we come eastward, and this tendency to assume more distinctively marine characters as we come eastward is shared also by some of the Tertiary formations as Mr. Langdon has sufficiently shown in his paper.

From this it will also appear that we cannot give any particulars of the paleontology of the Eutaw, since none of the plant remains of which such vast quantities have been noticed along the river bluffs above Finch's Ferry, are well preserved; they appear in the form of mere fragments of leaves, and twigs, and sometimes as lignitized trunks, impossible of determination.

ON THE PALEONTOLOGY AND THE GEOGRAPHICAL VARIATIONS IN THE LITHOLOGICAL CHARACTERS OF THE THREE UPPER DIVISIONS OF THE CRETACEOUS IN ALABAMA.

I am indebted to Mr. T. W. Stanton of the U. S. National Museum for a list of the fossils of the Ripley division of the Alabama Cretaceous, together with notes on the paleontology of the upper Cretaceous of the state, the substance of which is here presented. The principal forms occurring in the Eutaw beds below the Rotten Limestone in central Alabama, and below beds which have the lithological characters of the Ripley along the Chattahoochee, are *Ostrea Cretacea*, Morton, *Exogyra costata* Say, (a new variety intermediate between the typical form and *Exogyra ponderosa*,) *Gervillia propleura*, Meek, *Baroda*, species undetermined but probably *Carolinensis*, Conrad. *Placenticeras*, undetermined species. *Anomias*, undetermined species.

The fauna of the Rotten Limestone does not appear to be distinct from that of Ripley, its most abundant species are *Exogyra costata*, Say, *Gryphæa vesicularis*, Lamarck, and *Ostrea larva*. Lamarck.

The Ripley species are enumerated below.

Ripley Species.

Cassidulus æquoreus Morton.
" micrococcus Gabb.
" porrectus Clark.
Ostrea larva Lamarck.
" subspatulata Lyell & Sowerby.
Exogyra costata Say.
Gryphæa vesicularis Lamarck.
Anomia argentaria Morton.
Gervilliopsis ensiformis (Conrad)
Inoceramus proximus Tuomey.
" cripsi Mantell.
Pulvinites argentea Conrad.
Crenella serica Conrad.
Cucullæa littlei Gabb.
" vulgaris Morton.
Trigonarca cuneata Gabb.
Nemodon eufalensis Gabb.
Pectunculus subaustralis d'Orb.
Nucula percrassa Conrad.
Leda protexta Gabb.
Trigonia eufalensis Gabb.
Vetericardia crenilirata Conrad.
Cronotella vadosa Morton.
Crassatella pteropsis Conrad.
Cardium alabamense Conrad.
" eufaulense Conrad.
" dumosum Conrad.
" (Pachycardium) spillmani Conrad.
Venilia conradi Morton.
Cyprimeria depressa Conrad.
" torta Gabb.
Aphrodina tippana Conrad.
Solyma lineolata Conrad
Legumen planulatum Conrad.
Glycimeris decisa Conrad.
Pholadomya littlei Gabb.

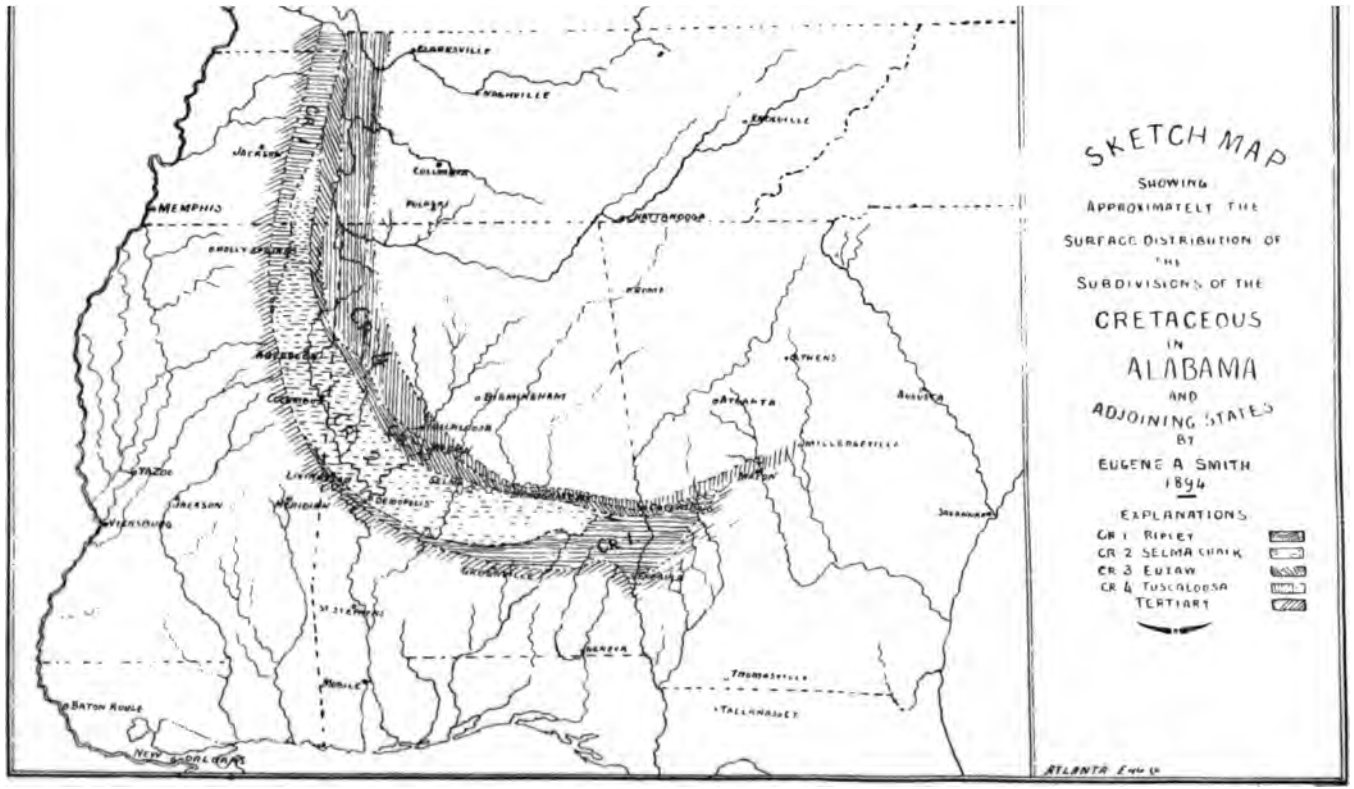
Anatimza postsulcata Conrad.
Liopistha protexta Conrad.
Corbula crassiplica Gabb.
Scala sillimanni Morton.
Turritella trilira Conrad.
" vertebroides Morton.
Lunatia obliquata H. & M.
Gyrodes petrosa Morton.
Anchura decemlirata Conrad.
Pugnellus densatus Conrad.
Nassa globosa Gabb.
Pyrifusus bellaliratus Conrad.
" subdensatus Conrad.
Strepsidura interrupta (Conrad)
Chemnitzia (?) melanopsis Conrad
Chemnitzia (?) laqueata Conrad.
Drillia (?) distans Conrad.
Liopeplum cretaceum (Conrad)
Volutomorpha eufalensis (Conrad)
Rotellities navarroensis (Shumard.)
Morea cancellaria Conrad.
Pleurotoma ripleyana Conrad.
Cinulia pulchella Shumard.
Baculites anceps Lamarck.
Placenticeras placenta (De Kay.)
Scaphites Conradi Morton.
Nautilus DeKayi Morton.

From these notes it appears to be impossible, on paleontological grounds, to separate the Rotten Limestone from the Ripley, and in eastern Alabama where the chalky rocks of the Rotten Limestone are in a great measure absent, the two divisions cannot be separated on lithological grounds, for the whole Cretaceous series, from about the mouth of Ihagee Creek on the Chattahoochee southward, is made up of bluish, micaceous, clayey sands, such as we are accustomed, in the central and western parts of the state, to associate with the Ripley. Above the mouth of Ihagee Creek the few fossils identified are such as characterize what we have been calling the Eutaw sands, which—or at least the part of them bearing marine fossils—are about the horizon of Dr. Hilgard's Tombigbee sands, and immediately below the Rotten Limestone or "chalk." This is the position of the fossiliferous beds of this age exposed at Choctaw Bluff, Erie, etc. At both these bluffs the true chalky Rotten Limestone makes the upper part of the bluff. The lower and by far the greater part of the Eutaw sands in the central and western parts of the state, have the fewest possible traces of marine fossils, being generally lignitic. On the Chattahoochee, however, beds with the marine species above enumerated, lie in direct contact upon the strata of the Tuscaloosa age, and the lignitiferous sands of the west appear to be wanting.

It seems, therefore, that we cannot, either by the fossils

or by the lithological characters, carry the distinction between the two upper members of our marine Cretaceous consistently across the state. This is the cause of some embarrassment when we come to represent these divisions on the map, and we have been forced, in the eastern part of the state, where the chalky strata of the Rotten Limestone fail, to color as Ripley an area which is undoubtedly made up of the time equivalents both of Ripley and of Rotten Limestone. Perhaps the better plan would have been to give the name Ripley to all the strata above the Eutaw sands, and distinguish between the clear sea or open sea deposits of chalky nature, and the littoral deposits which we have most commonly had in mind when we have used the term Ripley. As subdivisions of the Ripley, on this plan, we might use the names *Selma Chalk*, and *Cowikee marly sands*, since the Cowikee creeks traverse nearly the whole breadth of this formation where the chalky beds are absent.

An examination of the distribution of the Cretaceous formations in the adjoining states will make the condition of things in Alabama more easily understood, and for this purpose the accompanying sketch map has been prepared, Plate XVI. Of all the Cretaceous formations the Tuscaloosa is the most widely distributed. It continues eastward along the foot hills of the Appalachians to Maryland and beyond. The other divisions have not been traced eastward beyond the western part of Georgia. The map will show how in the upper half of Tennessee the whole Cretaceous, above the Tuscaloosa, is represented by littoral or off-shore deposits, chiefly sandy, in which there are a few fossils of Eutaw species in the eastern or lower part and of Ripley species in the western. In the eastern part of Alabama we have a similar state of things, for along the Chattahoochee River the lower parts of these sandy strata hold Eutaw species and the rest Ripley species, all the strata being of littoral or off-shore character. Below the central line in Tennessee the chalky beds of the Rotten Limestone wedge in between these two sandy series and gradually narrow down or crowd out the


SKETCH MAP
SHOWING
APPROXIMATELY THE
SURFACE DISTRIBUTION OF
THE
SUBDIVISIONS OF THE
CRETACEOUS
IN
ALABAMA
AND
ADJOINING STATES
BY
EUGENE A SMITH
1894
EXPLANATIONS
CR 1 RIPLEY
CR 2 SELMA CHALK
CR 3 EUTAW
CR 4 TUSCALOOSA
TERTIARY
CR 1
CR 2
CR 3
CR 4
MEMPHIS
JACKSON
COLUMBUS
PONTOTOC
CORINTH
FLORENCE
TUSCUMBIA
DECATUR
HUNTSVILLE
GUNTERSVILLE
ATHENS
BIRMINGHAM
ATLANTA
ANNISTON
MILLEDGEVILLE
TALLADEGA
TUSCALOOSA
GREENSBORO
DEMOPOLIS
MERIDIAN
VICKSBURG
JACKSON
NATCHEZ
WOODVILLE
ST STEPHENS
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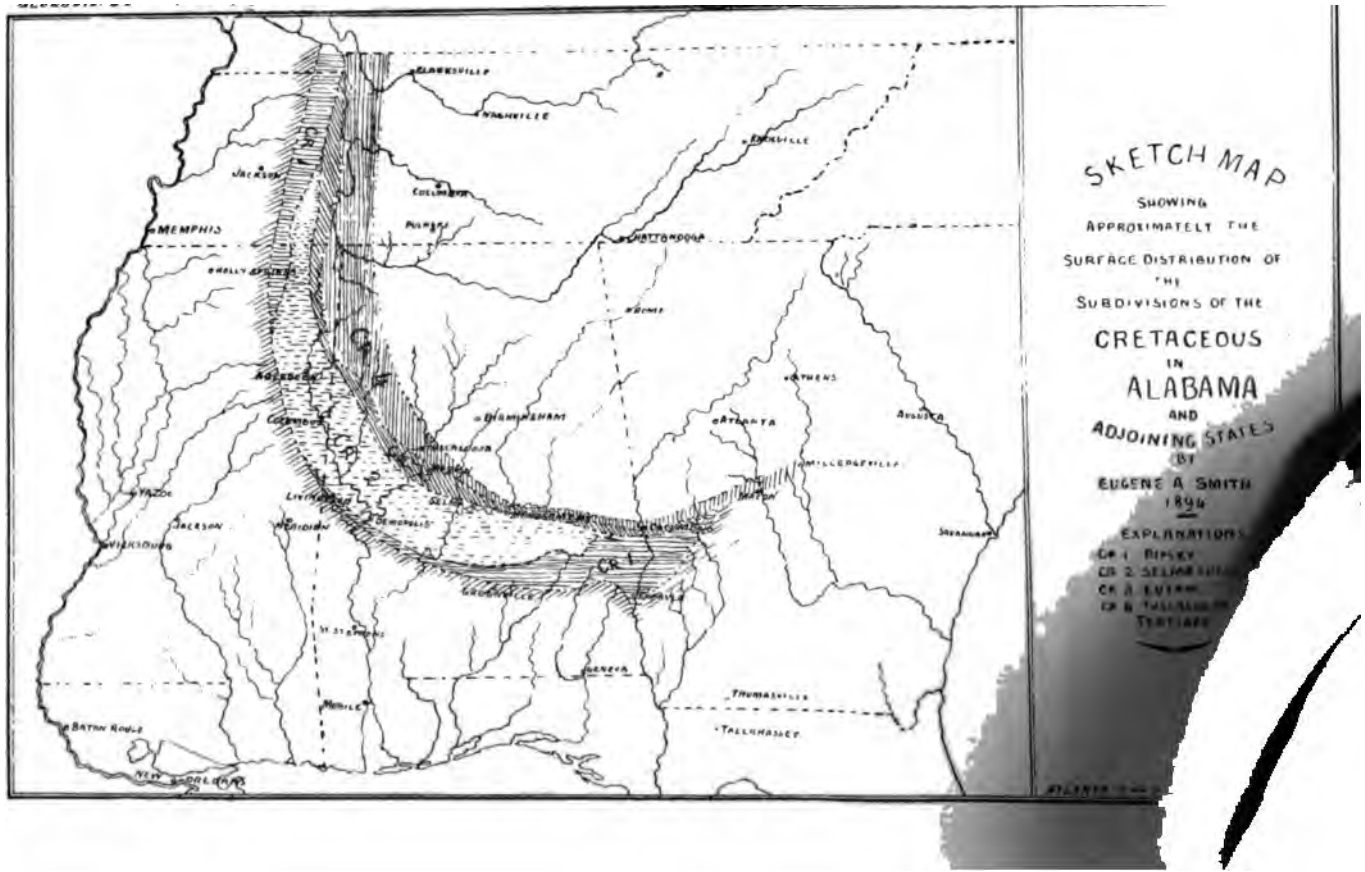
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(*l*) *Section at Hickman's, Tuscaloosa River.*

1. Cross bedded sands of yellowish color on exposed surfaces, probably 10 feet or more in thickness.
2. Laminated, blue clays, more or less sandy and containing lignitized tree trunks, which are, in general, pyritous. The laminated, blue strata in the upper part of this division are much more clayey than those in the lower part, and mark the bluff with parallel and approximately horizontal stripings, probably 5 to 10 feet.
3. Cross bedded sands again down to the water's edge.

At the head of Big Log Shoals we have another section of ten or twelve feet, as follows:

(*m*) *Section at the head of Big Log Shoals, Tuscaloosa River.*

1. Compact, blue, micaceous sands.....3 to 4 feet.
2. Laminated sands.....3 to 4 feet.
3. Lignitic stratum, consisting of lignitized twigs, stones, and other fragments. embedded in bluish sands.....1 foot.
4. Alternating layers of blue clay and bluish, micaceous sands, the latter including a bed of pebbles 8 to 10 inches in thickness.....4 to 5 feet.

This section represents the lowermost of the blue clays and cross bedded sands, which we have considered as belonging to the Eutaw formation of the Cretaceous group, leaving undetermined some seventy-five feet from this to White's Bluff. At the latter begins our Tuscaloosa formation which will be the subject considered under the next heading.

Mention has frequently been made above of the fact that organic remains other than those of vegetable origin are practically absent from the strata of the Eutaw formation. This is true as regards the formation westward of Montgomery, or perhaps I should say westward of Selma.

At Prattville in Autauga county, the banks and bed of the creek are formed of a yellowish calcareous sand which contains numerous traces of marine or estuarine shells. These are however, as a rule so friable and so completely decayed that it has been impossible to determine any of the species. In some cases the calcareous matter of the shells is in the form of lumps of pulverulent carbonate of lime.

On the Chattahoochee river we find a bluff at Broken Arrow Bend where strata resting directly upon the Tuscaloosa formation contain marine shells, but here also they are of a nature to give us very little if any assistance in determining the exact geological horizon although in general corresponding pretty closely with forms occurring immediately below the Rotten Limestone at Choctaw Bluff on the Warrior River. From the relation to the underlying Tuscaloosa beds we have considered them to be Eutaw strata. The section at the point named is as follows:

(*n.*) *Section at Broken Arrow Bend, Chattahoochee river.*

(1.) Dark gray micaceous sands, with indurated ledges at intervals of 2 or 3 feet. These ledges are quite calcareous and hold many shells of exogyra, etc..... .. 20 ft.
(2.) Cross bedded sands and mottled clays, (Tuscaloosa).... 7 ft.

At other bluffs a short distance further down the river, strata overlying No. 1, of the above section appear, and some of these contain a great number of impressions of shells in a clayey matrix. These shells also appear to be impossible of determination. These instances will serve at least to exhibit the change in the character of the Eutaw formation as we come eastward, and this tendency to assume more distinctively marine characters as we come eastward is shared also by some of the Tertiary formations as Mr. Langdon has sufficiently shown in his paper.

From this it will also appear that we cannot give any particulars of the paleontology of the Eutaw, since none of the plant remains of which such vast quantities have been noticed along the river bluffs above Finch's Ferry, are well preserved; they appear in the form of mere fragments of leaves, and twigs, and sometimes as lignitized trunks, impossible of determination.

ately overlying the strata of the undoubted Tuscaloosa age. So far as our observations go the beds of the Tuscaloosa formation contain no traces of marine fossils, but in many localities a great abundance of beautifully preserved leaf-impressions, and in one locality at least, a bed of lignite. While the materials of both formations are clays and sands there is yet difference enough between the two to enable the observer as a rule to distinguish them in the field

Since the formation to which the purple clays and associated strata belong is clearly distinct from those already recognized and named in Alabama, and since it cannot be co-ordinated with certainty with any other formation in this country, it seems desirable that it should receive a specific designation. We therefore propose for it the name *TUSCALOOSA FORMATION*, first suggested by Mr. McGee, after the name of the city at which and the river along which its typical exposures occur. It is now pretty definitely known that our Tuscaloosa formation is in the main the equivalent of the Potomac of the Atlantic States.

The stratigraphic relations of the Tuscaloosa formation may be seen by reference to the general section (Plate XXVIII and XXIX). In constructing this part of the section we have assumed a uniform dip towards the southwest of forty feet to the mile, and the indicated thickness is, accordingly, only approximate.

Details.

Along the Warrior River; *Rock Bluff*.—Between Big Log Shoals and White's Bluff no rocks are seen along the river banks, except at Rock Bluff, where a pebbly conglomerate with ferruginous cement forms a bluff and, lower down the river, a rocky reef. This rock is underlaid by a gray or bluish clay. The position of this stratum is about twenty-five feet below the lowest of the Eutaw beds as exposed at Big Log Shoals.

At *White's Bluff* we see the first of a series of purple and

mottled clays with interstratified sands, which occur at intervals as high up the river as Mrs. Prince's Landing, near Carthage. At the lowest estimate, these clays and sands are 275 feet in thickness.

In detail, the sections exposed along the river, in geologically descending order, are as follows:

(*a*) *Section at White's Bluff, Greene County, Tuscaloosa River.*

1. Purple clay, mottled with irregular patches of gray clay, both purple, and gray portions sandy.. .....10 feet.
2. Micaceous sands of light, nearly white color.....1 foot.
3. Light colored sands, with little or no mica.....14 feet.

A few miles higher up the river the same beds are again seen at *Steele's Bluff*, as follows:

(*b*) *Section at Steele's Bluff, Tuscaloosa River.*

1. Purple and mottled clays.....10 feet,
2. Light colored, often nearly white, coarse grained sands, holding a few small pebbles in places; the pebbles mostly of chert, not quartz.....10 to 12 feet.

The sands in the above section are in places strongly cross-bedded and on exposure to the atmosphere show a tendency to harden into a pretty firm sandstone, which is, however, quite friable and easily rubbed down between the fingers after the thin outside coating of harder material has been removed.

At *Battle's Landing* there is a thin bed of ferruginous sandstone, extremely hard and firm and very similar to the ferruginous rocks so often formed in the Lafayette beds.

At *Williford's Landing* the purple clay shows from the water's edge about ten feet in thickness, and over it occur Second Bottom or river deposits. Between the two a great number of bold springs of very pure water break out. An artesian well, said to be 400 feet deep, was bored at this place thirty or forty years ago, but no record of the boring is now to be had. The water flows out at the top and is not salty. This is the farthest north of any of the artesian wells of

Middle Alabama. The locality is Sec. 31, T. 24 N., R. 4 E., in the lower edge of Tuscaloosa county.

Just above Williford's Landing and at *Bealle's Landing* there are reefs of rock forming shoals at low water. These rocks are sandstones and conglomerates, with ferruginous cement, similar to that already noticed at Battle's Landing.

We see the last outcrop along the river of the purple mottled clays at *Mrs. Prince's Landing*,* where they are about six or eight feet above the water's edge.

Between Mrs. Prince's Landing and Tuscaloosa the immediate banks of the river are with few exceptions formed by the loose materials of the Second Bottom deposits. At one or two places, however, given below, appear exposures of more ancient rocks. With a uniform dip of the strata, the distance between Mrs. Prince's Landing and Tuscaloosa would represent a thickness of more than five hundred feet, only forty or fifty of which are at all exposed along the river.

Saunder's Ferry.—At or near Saunder's Ferry, just below the Twelve Mile Rock, there is a fine exposure made by a landslide.

The full section is as follows:

(*c*) *Section above Saunder's Ferry, Tuscaloosa River.*

1. Rather massive clays of greenish and purple colors, breaking with conchoidal fracture. On drying these clays become hard and rock-like, resembling then, except in color, some of the claystones of the Buhrstone formation. These clays when wet soften and slide down the slopes, covering them completely in places. In this clay we find many rounded masses of ferruginous and silicious matter of oölitic structure. Thickness of the clays.....40 feet.
2. Laminated, sandy clays, gray, with sand partings.....5 feet. This bed is rather more coherent than the underlying and forms a slightly projecting or overhanging ledge.
3. Gray, cross-bedded sands, with partings of clay along many of the planes of false bedding.....25 feet.

*They may be seen, however, above Mrs. Prince's in many places, in the hills a few rods back from the immediate banks of the river. See section (*c*).

This and the preceding might readily be considered together as one member, more clayey in the upper five feet and sandier below, and this is our grouping of 1883. In these beds we find a good deal of lignitic matter and some leaf impressions very well preserved.

4. Slope or bench forty to fifty feet wide, covered by red clay and sands, slidden down from No. 1 and washed out of Nos. 2 and 3.....3 feet.
5. Gray or whitish, cross-bedded sands, forming the immediate bank of the river.....15 feet.
6. Blue, micaceous sands to water level.....5 feet.

This section of 140 feet is undoubtedly of Tuscaloosa materials.

At *Venable's Landing* there is a sandstone bluff 15 to 20 feet high, formed of bluish, micaceous sands indurated into a tolerably firm rock in places. The bedding planes of this rock are strongly ferruginous and numbers of chalybeate springs break out from the sides of the bluff.

About five and a half miles below Tuscaloosa there are to be seen at the water's edge some rocks which consist of sandy clays somewhat indurated. These clays are interstratified with thin beds of lignitic matter, with black scales resembling graphite disseminated through it. The lignitic matter consists of indistinguishable impressions of leaves and stems, and occasionally throughout the mass are nodules of iron pyrites, and not unfrequently fragments of stems lignitized or converted into charcoal, coated externally with a thin shell of pyrite.

In the banks of the branch at the University of Alabama there is a very similar small remnant of the Tuscaloosa formation, mottled clays, embedded in the red loam. The same, mottled purple and gray, appear at several places along the road leading from the University to the city of Tuscaloosa and in the gullies back of the city toward the river. In many of these localities the clays have evidently been partly redistributed, drift fashion, but in one or two places we see the undisturbed beds, consisting of dark bluish gray, nearly black clay, in laminæ (half an inch thick), separ-

ated by partings of white sand, six or eight feet thick, with white and yellowish, strongly cross-bedded sands underlying them. It is difficult to determine the thickness of these sands, as they are so hidden by the debris from above, but it is not less than 20 feet.

In one of the gullies back of Tuscaloosa we get the following section:

(*d*) *Section in Tuscaloosa.*

1. Pebbles, sand and red loam, of the Lafayette, forming the plateau on which the city of Tuscaloosa stands.....15 feet.
2. Light gray, somewhat massive clays, mottled with yellow, but becoming laminated below.....8 feet.
3. Dark blue, nearly black, laminated clays, laminæ half an inch thick, separated by thin partings of white sand. The clay contains the leaf impressions which have been examined.....8 feet.
4. Yellowish gray, laminated clays, also containing a few leaf impressions, of rather variable thickness .....2 feet.
5. Strongly cross bedded, yellowish or nearly white, sharp sand, with a few streaks of clay irregularly distributed through it. Thickness uncertain, but not less than.....20 feet.

We cannot say what lies below the sands, since the strata of this formation about Tuscaloosa have suffered a great amount of denudation and their outcrops appear only here and there. The erosion hollows have been filled in with pebbles and sands of the Lafayette, often to the depth of fifty or sixty feet. These circumstances and the fact that the clays themselves have in places been broken up and redeposited in lumps among the Lafayette pebbles have caused this formation to be overlooked or confounded with the Lafayette. The dark gray, laminated clays above mentioned contain many beautifully preserved leaf impressions, which are now being studied and which will probably fix definitely the age of the formation.

It will thus be seen that the exposures along the river give us an insight into the composition of only a very small proportion of the strata which underlie the purple clays.

TUSCALOOSA, HALE AND GREENE COUNTIES.—We have referred above to the observations of Prof. Alexander Win-

chell, made many years ago upon this formation. These observations were recorded in the Proceedings of the American Association for the Advancement of Science, Vol. X, Part II, p. 93, 1856, from which the following extract is made: "At about eight miles above Eutaw the shale becomes softer, the lamination disappears, and we have beds of light clay, mottled curiously with blue, red and yellow, reminding one forcibly of the Keuper of the Germans. More than this, we find along the roadsides and the margins of the ravines in the upper part of Greene county large masses of red and poikilitic sandstone, exceedingly compact, and used for underpinning buildings. Add to this that very many of the artesian wells in Greene county, which penetrate these beds, furnish a constant flow of salt water, showing the occurrence of local deposits of salts, while the deepest borings have brought up abundance of quartzose pebbles, and we have four well established facts compatible with the supposition of the Triassic age of these beds, without mentioning the occurrence of vegetable remains, some specimens of which appeared to me indistinctly allied to stems of *Equisettes.*

These beds continue without much change to the very suburbs of Tuscaloosa; and a very good section is seen at Foster's Ferry, within a few miles of town.

The almost total absence of organic remains from these shaly and poikilitic deposits renders the determination of their age extremely uncertain."

It seems probable that the red sandstone mentioned by Prof. Winchell is the same as that occurring at Battle's Gin, on the river, and at Havana, presently to be described.

On going by land from Tuscaloosa to Eutaw, on the western side of the river, in 1886, we have been able to repeat the observations of Professor Winchell. Two miles west of Saunders' Ferry and about ten miles west of Tuscaloosa, the road passes by the edge of a great gully washed out of materials of the Tuscaloosa formation. This gully is of nearly

100 feet perpendicular depth, and the bottom slopes then very gradually down forty or fifty feet more.

(e) Section of gully 10 miles west of Tuscaloosa.

1. Pebbles and red loam (Lafayette)..... 10 feet.
2. Sharp, yellowish, cross bedded sands, with thin strings of light yellow, chert pebbles, subangular and in many cases showing casts of encrinital buttons and bryozoans and other sub-Carboniferous fossils..... 20 to 25 feet.
3. White and red, laminated clays of very irregular thickness, often discontinuous..... 5 feet.
4. Firm, yellowish sands..... 12 feet.
5. Bed of subangular, white and yellow chert pebbles, with sub-Carboniferous fossils..... 2½ feet.
6. Red clay in irregular beds or pockets..... about 3 to 4 feet.
7. Yellowish white sands, with thin streaks of pebbles..... 8 feet.
8. Red clay and sand..... 1 foot.
9. Strongly cross bedded yellow sands, with thin irregular sheets of clay following some of the lines of false bedding..... 35 feet.

Below this, cross bedded sands with clay partings continue to the lowest part of the gully, probably 40 feet below the above section.

From this place down to Knoxville nearly every hill reveals the materials of this formation, consisting mainly of yellowish and reddish, cross bedded sands, with clays (red and purple) sparingly interspersed. The section of the gully above given might be taken as typical of the strata exposed over this entire distance.

In places the sands are cemented by iron into quite firm sandstones, which are quarried for rough work. The rock can be easily cut when freshly dug, but it soon hardens on exposure. I am strongly inclined to believe that the red sandstones and conglomerates seen at Battle's Gin, above Williford's Landing, near Havana, &c., are bedded rocks of this formation; at any rate the constituent sands are of this age, while the induration into rocks by the ferruginous solutions may have occurred in comparatively recent times.

A short distance south of Knoxville we lose sight entirely of the red and purple clays which have been to us a char-

acteristic of the Tuscaloosa formation, and begin to encounter the glauconitic, cross bedded sands, laminated clays, and other materials which we have classed with the Eutaw formation. If we assume a dip of 30 or forty feet to the mile, estimating from the width of outcrop, there will be some 900 feet or more of the Tuscaloosa and 300 to 400 feet of the Eutaw formation.

Other points of difference between the Tuscaloosa and Eutaw beds are worthy of mention. Both formations hold occasionally thin beds of pebbles, which are not however, in extent to be compared with the pebble beds, belonging to the Lafayette formation. The pebbles of the Tuscaloosa formation are as a rule, subangular, of chert, and in many cases fossiliferous, i. e. they contain casts of sub-Carboniferous fossils, the pebbles of the Eutaw are well rounded, of quartz, and non-fossiliferous so far as our observations go. Cross-bedded sands make up the greater part of both formations, but the cross bedding of the sands in the Tuscaloosa formation is generally much less pronounced than in the Eutaw, as if effected in less rapidly flowing waters. In the Eutaw sands the different layers are more frequently separated by thin sheets of clay than is the case with the sands of Tuscaloosa. Near the base and the summit of the Tuscaloosa series we find heavy beds forty feet or more in thickness, of massive clays of red, purple and greenish colors, and also sparingly distributed through the whole of the formation, are thinner beds of similar clays. No beds of this character have ever been observed in what we have called the Eutaw formation. Both formations contain leaf impressions, lignitized trunks of trees, and thin beds of lignite, but it has not yet been possible to obtain any determinable specimens from the Eutaw, though at Merriwether's landing and elsewhere the laminated clays are full of fragments of leaves, etc. The Eutaw contains many feet thickness of marine deposits, which are chiefly sandy but contain abundance of glauconite, as well as very badly

preserved marine shells. As yet nothing of this kind has been observed in the Tuscaloosa formation. It may be objected that these marine beds of the Eutaw pertain to the division named by Dr. Hilgard, the Tombigbee sands, which Dr. Hilgard as well as Dr. White and others agree in considering a subordinate member of the Rotten Limestone; but these glauconitic sands occur at the very base of the Eutaw as well as (sparingly) all through it in Eastern Alabama, and the marine shells above spoken of are found at Prattville well down below the base of the Rotten Limestone, while on the Chattahoochee river at Broken Arrow Bend, we find marine shells in the beds immediately overlying the Tuscaloosa, and therefore, by inference, near or at the base of the Eutaw.

In the Lafayette, the Eutaw and the Tuscaloosa formations we have three groups of very similar strata, whose distinctive characters it is difficult if not impossible to describe in words, since cross-bedded sands with interspersed sheets of clay and pebbles, prevail in all three; yet in the field the differences are so easily recognized in the topography, the timber, the color and other qualities of the soils, etc., that we are never long in doubt as to which formation we have under consideration.

Along the road leading from Tuscaloosa to Greensborough on the eastern side of the river the first outcrop of the Tuscaloosa formation is seen on Little Sandy Creek. It is as follows:

(f) Section on Little Sandy Creek, Tuscaloosa County.

1. Micaceous, yellow sands, including a thin streak of gray, lignitic clay, with small pieces of lignitic matter.....10 inches.
2. Gray, laminated clays, highly micaceous..... 6 feet.

On the south side of this creek irregularly bedded sands are seen above these strata and near the top of the hill are purple and mottled clays with cross bedded sands. At the foot of the first hill south of Little Sandy we see the first

occurrence along this road of the heavy purple clays characteristic of the formation.

Farther along the road the thickness of the purple clays is seen to be at least 50 feet and they crop out along the hillsides for a good many miles. It is easy to recognize them even without close examination, for wherever they come to the surface in the roads it is necessary to lay down a causeway, since in wet weather the tenacity of the clay is so great that the road would otherwise be impassable.

At the old Frierson place which is on the summit of the hill on the north side of Big Sandy, and all down the slope of the hill to the creek bottom are variegated sands with prevailing yellowish tints with here and there spots of red and gray, and many irregular bunches of small pebbles embedded in the sands.

On the south side of Big Sandy Creek we get again a very good section of the purple clays which form the lower members of the Tuscaloosa formation, as follows:

(*g*) *Section on Big Sandy Creek, Tuscaloosa County.*

1. Purple and mottled clays like those occurring at Steele's Bluff, on the Tuscaloosa River.....30 feet.
2. Light yellow sands, with pebbles, also similar to those seen at the above named locality and at White's Bluff.....10 to 15 feet.
3. Gray, laminated clay, inclosing a lignitized tree trunk, at base of hill.....4 to 5 feet.

Near the Newton Whitfield place just beyond Big Sandy, occur great blocks of ferruginous sandstone which may be seen at intervals down to Havana where it is most perfectly displayed in a ravine back of the town. Here it forms perpendicular bluffs ten to twelve feet in height.

Large masses of the rock have split off from time to time and rolled down into the gorge below.* It has been thus

*Underneath the ledge of rock shallow caves have been washed out, and in these flourish several rare ferns, especially *Asplenium ebenoides* Schw., which was discovered here by Miss Julia Tutwiler and is interesting from the fact that it is known to occur elsewhere only along the banks of Schuylkill River. Besides this fern, there are *Camp-*

far impossible to determine whether this conglomerate is formed by the induration of the sands of the Lafayette formation or constitute a member of the Tuscaloosa. Its great extent and persistence seem to favor the supposition that it belongs to the older formation, yet it is in appearance quite similar to a conglomerate of very common occurrence in the Lafayette, only much thicker, and more widely extended. This rock has been observed on both sides of the river and over an area of at least 200 square miles.

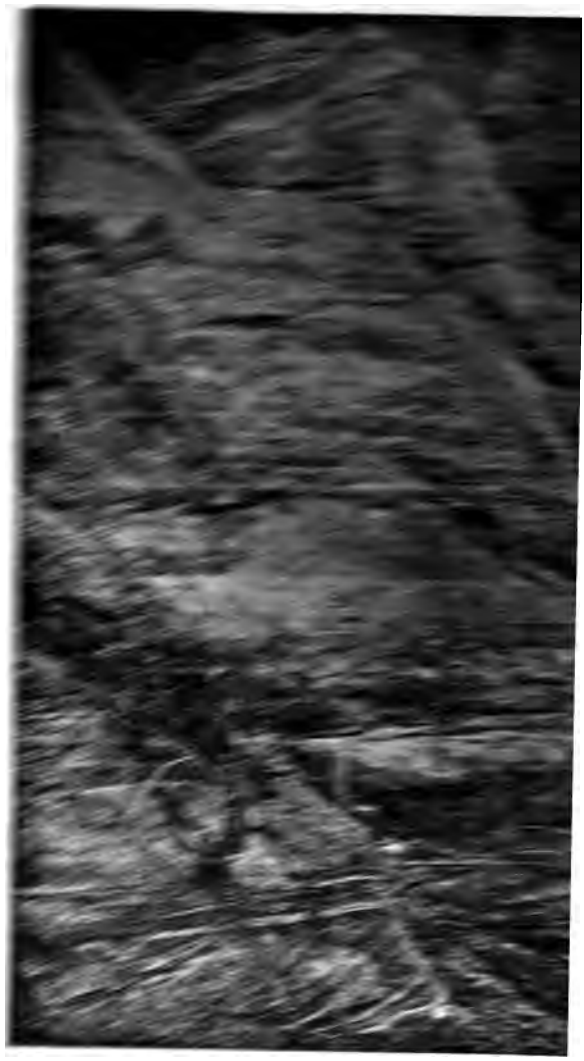
Below Havana near the residence of Hon. A. M. Avery, there are several very deep gullies near the road where the uppermost beds of the Tuscaloosa formation are beautifully exposed (Plate XVII). These beds are as follows:

(h) Section two miles south of Havana, Hale County.

1. Red surface loam, forming exceedingly fertile soil....10 to 15 feet.
2. Yellow sands and pebbles, conformable in stratification with the underlying strata.....10 to 12 feet.
3. Purple and pink, micaceous, argillaceous sands, most beautifully cross bedded.....20 to 30 feet.

That these deposits lie very near the summit of the Tuscaloosa formation is evident from the fact that the cross bedded, glauconitic sands of the Eutaw formation occur at the surface only a very short distance to the southward. The red loam forming the uppermost of the section resembles in some degree the usual red loam of much of the southern part of the State, except that it is of much deeper color and apparently more fertile than most of these loams. It may however, be derived from the disintegration of the glauconitic sands of the Eutaw formation or from the uppermost of the Tuscaloosa formation. The pebble bed No. 2 resembles also in some degree the pebble beds of the Lafayette, but as it is entirely comformable in stratification with the un-

tosorus rhizophyllus or walking leaf, *Trichomanes radicans*, and *Aspidium marginale*. The appearance of this conglomerate and the ferns growing in the shallow caves beneath it recall very forcibly the Carboniferous conglomerate which forms the surface over so great a part of the counties of Marion and Winston.



lying beds (a circumstance of rare occurrence in the La-ette), I am inclined to consider it a part of the Tusca-sa formation. The sands No. 3 also differ from anything ich occurs in the Lafayette, and I have seen the like y at one other place, viz., on Mulberry Creek, in Autauga nty, near the residence of Hon. James W. Lapsley.

Havana stands upon a plateau some six miles long north l south and two miles wide east and west. On the west s plateau overlooks the terrace or Second Bottom of the rrior River, and on the east it is bordered by broken and ly lands. The soil and subsoil are of deep red color, and nsist of a sandy loam, which is very productive. The ber prevailing upon these lands is post and black oaks h a few white oaks, hickory short leaf pine and sour gum. hile the materials forming the soil and subsoil appear to derived from the Lafayette formation, they are yet of her more than average fertility.

It is quite possible that the underlying glauconitic sands the Eutaw formation are responsible for a part at least this fertility.

A somewhat similar red loam plateau may be seen in the per part of Autauga county above Vine Hill. In the vi-ity of Havana are many fine old homesteads.

In going eastward from Tuscaloosa along what is known the Huntsville road, we have ample opportunity for see-g the various phases of this formation. Between the city d the University there are many outcrops of the mottled y which is derived from the Tuscaloosa formation, though many cases worked over and redeposited among the ma-ials of the Lafayette. Beyond the University the lower rts of Castle Hill are made up of the same materials, with apping of the red loam and pebbles of the Lafayette.

About four miles from the town may be seen the summit a rounded mass of the strata of this formation, consisting two or three feet of purple, gray and variegated laminated ys, underlaid by about the same thickness of cross-bedded

sands. This exposure lies plainly unconformably embedded in the red loam of the Lafayette.

At the Box Spring, about five miles east of Tuscaloosa, the railroad cut exposes 6 to 8 feet of laminated, gray clays marked with purple streaks. Immediately above these is a very persistent ledge of ferruginous sandstone and over that 10 or 12 feet of sand and loam of more recent date.

Between this point and Tuscaloosa the railroad cuts furnish a number of splendid sections of the Tuscaloosa beds, which include a bed of fine white clay of great purity. In the cut nearest the Box Spring, the irregularity in the bedding and the induration of part of the sandier strata into a hard rock, are most conspicuous features.

Beyond the Box Spring exposures of similar strata occur at many points along the dirt road and in most of the railroad cuts. At Cottondale, we have the best section exposed in the cut, just beyond the station. Here the Tuscaloosa strata appear to have a decided dip to the west*, and are unconformably covered by the irregularly deposited pebble beds and red loam of the Lafayette. These relations are well shown in the frontispiece plate. Across Hurricane creek the cuts expose a good deal of the purple clay which causes landslides and consequent damage to the railroad track.

About nine miles east of Tuscaloosa, beyond Cottondale, 30 to 40 feet thickness of purple clays is seen along a hillside. In these clays there are two ledges of ferruginous sandstone or, perhaps more properly speaking, of sandy iron ore. The clays are a mixture of purple and yellow and appear to form the lower strata of the hill for 20 or 30 feet below those above described. The iron ore which covers so much of the slope of this hill is somewhat sandy, occasionally quite pure and compact, giving a red streak. It differs very materially from the usual limonite of the valleys, and might perhaps be classified as *turgite*.

*A similar very decided dip in the Tuscaloosa strata may be seen at many points, as far north and east as Woodstock.

About twelve miles east of Tuscaloosa the grayish purple clays similar to those described between the two branches of Sandy Creek appear in many places along the slopes of hills where they are laid bare by the road.

(*i*) *Section 10 miles east of Tuscaloosa.*

1. Ferruginous sandstone in sheets.....6 to 8 inches.
2. Variegated, clayey sands holding small pieces of purple clay. The sands show chocolate, purple, red and yellow colors..6 to 8 feet.
3. Purple clays, with partings of sand; similar to the purple clays south of Tuscaloosa.....10 feet.
4. Ledge of ferruginous sandstone.....1 foot or more.
5. Laminated, gray and yellow, sandy clays or clayey sands, yellow at top and shading into gray at bottom.....6 to 8 feet.
6. Lignite, with pyrite nodules.....2 to 6 inches.
7. Dark gray, somewhat massive clays, becoming lighter below 6 to 8 feet.
8. Strata obscured by washings from above.....20 feet.
9. Purple clay at base of hill.....undetermined.

In some places near this, five feet of purple clays are seen overlying No. 1 of the section.

The bed of lignite No. 6 has been cut into near this place where its full thickness is exposed. It was probably mistaken for a seam of coal.

Near the base of this hill the clays contain great quantities of beautifully preserved leaf-impressions and large collections were made here by Prof. Fontaine. The collections have not yet been thoroughly studied, but some of the species are named below.

In the direction of Scottsville exposures of the clays and sands of the Tuscaloosa extend to the borders of the county, and we shall speak of these again under the head of Bibb county.

Going westward from Tuscaloosa along the Carrollton road some four miles from town, a bed of laminated clays with leaf-impression occurs.

Beyond this as far as twelve miles from town, the prevailing material of the Tuscaloosa is a heavy bedded gray

clay which requires a causeway wherever it is passed along the road. These clays upon exposure for instance in gullies and on the surface, undergo a series of changes in color; first the gray becomes specked with red which gradually increases in proportion till, where the oxidation is complete, we have a reddish clay with only a few fragments of the original gray intermixed.

The mottled clays so often mentioned are usually modifications of the gray clay brought about in the matter described.

These heavy bedded clays prevail in the western part of Tuscaloosa county along the Columbus road to the border of Pickens and beyond. The soil over much of this territory seems to be very good and supports a forest growth of black jack, post, red (Spanish), and white oaks, with some short leaf pine, and sweet and sour gums. As we go westward sandy beds are seen interstratified with the clays.

In Pickens, Lamar, Fayette, and Marion.—In the Eastern and Southeastern parts of Pickens, there is a prevalence of the heavy clay beds above noticed, but further westward and northward the material of the Tuscaloosa becomes more sandy, in many places holding thin sheets of small pebbles of chert of subangular shape often containing casts of Subcarboniferous fossils. At intervals these sands become indurated into hard rocks which are, however, of limited extent and altogether local. Most of the hill tops in northeastern Pickens are capped with fragments of ferruginous crusts formed by the cementing together of the sands by iron oxide. Such iron crusts occur frequently also where the sands of the Lafayette form the surface.

Throughout Lamar county the strata of the Tuscaloosa formation make up the greater part of the surface, though the red loam and pebble beds of the Lafayette formation overlie the Tuscaloosa beds in many places, where, because of the similarity of much of the material of the two formations, it is often impossible to distinguish between them. In a general way the Tuscaloosa strata of Lamar county con-

sist of sands and pebble beds, with thin sheets of white, gray, pinkish and red clays inter-stratified. Between Kennedy station and Fayette C. H., the road is over a succession of sandy and gravelly hills, usually capped by the iron crusts above mentioned. Between Fayette C. H. and Vernon, the country, so far as it lies in Lamar county is similar. Near Vernon the gravel beds contain very good limonite which is in sufficient quantity and of sufficiently good quality to be used in a furnace during the war. In a well between Vernon and the ore banks, a thin sheet of lignitic matter was cut.

Northeastward of Vernon in the direction of Pikeville, the road is generally along a ridge and beds of angular chert pebbles are abundant.

These pebbles occur both in loose masses and cemented into hard conglomerates. Conspicuous in this part of the State is the rarity of well rounded quartz pebbles, so frequently seen further east, most of the pebbles in Lamar being angular, or not well rounded and of cherty material often holding casts of Subcarboniferous fossils. The prevalence of these subangular chert pebbles seems to be a mark of distinction between the Tuscaloosa formation and the Lafayette, in which many of the pebbles are well rounded and of quartz. I must add, however, that it is in many cases impossible to be certain upon stratigraphic grounds, as to which of these two formations a given bed of pebbles belongs.

In a gully near Moscow, we have a very good and characteristic section of the Tuscaloosa strata, which is as follows:

(j) *Section of Tuscaloosa strata North of Moscow, Lamar Co.*

1.	Pebbles and red loam forming the surface.....		
2.	Yellow sand, reddish in lower part.....	1 ft	6 inches.
3.	White plastic clay.....		8 "
4.	Chert pebbles interstratified with sands.....	3 ft.	0 "
5.	Yellow sand.....	1 ft.	6 "
6.	Yellowish and whitish plastic clay.....		8 "
7.	Yellow sand.....	5 ft.	0 "
8.	Sand and pebbles to bottom of gully.....	2	0 "

In this section the bands of different materials are very clearly marked and distinct, and run parallel to one another the whole length of the section, fifty feet or more. Just above the two clay layers the sands are indurated by ferric oxide into pretty hard crusts. The pebbles of this section which seems to be of Tuscaloosa material throughout except possibly the uppermost bed of red loam and pebbles, are of chert and more or less angular. The pebbles do not seem to be common above an elevation of 175 feet above the waters of the creeks and other streams.

In the northeastern part of the county adjoining Marion, and especially in the depressions of the watercourses, rounded quartz pebbles are occasionally found mingled with the much more abundant angular chert pebbles.

The eastern part of Fayette county is traversed north and south by the Byler ridge, in great part made up of the strata of the Tuscaloosa and Lafayette formations. As far west as the Court House heavy bedded clays of white, gray and purple colors are frequently met. Just southwest of the Court House the Tuscaloosa strata are mottled clays with beds of fine light yellow colored sands containing much mica, with partings of clay; below all a bed of fine white clay. This same clay occurs in quantity below the level of the flat on which the Depot is located. At Mr. Sam Appling's, S. 24, T. 15, R. 13 W., a bed some six feet thick of pure white clay has been cut in a well. In the northwestern part of the county are many occurrences of the purple clays.

The surface of this county is pretty generally covered with pebbles, which as usual are of two kinds, angular chert pebbles with many Subcarboniferous fossils, and well rounded quartz pebbles. The latter appear as a rule to belong to the more recent Lafayette formation while the former are often seen in place embedded in the other strata of the Tuscaloosa, though they may also be seen in localities where it is impossible to say whether they belong to the older or to the newer of these two formations. In the drainage area of New River we find the greatest quantity of these rounded

quartz pebbles, while to the west of it the angular chert gravel is much more abundant and at times the only sort to be seen. Five or six miles north of the Court House, the angular pebbles predominate greatly over the rounded ones, and cemented together into a conglomerate, they form a ledge of hard rock overlying a bed of white clay over considerable extent of country. About Ballard are some fine oak and hickory uplands with a little short leaf pine, constituting one of the most attractive parts of the county. North of this and within a mile or two of the Marion county line, we see a great abundance of angular chert gravel, and in several places beautiful bold and clear springs break out through this gravel much after the fashion of the bold lime springs of the Subcarboniferous formation. In this case, however, there seemed to be no considerable amount of lime in the water.

Along the line of the Kansas City Railroad in the lower part of Marion county are cuts in which the leaf-bearing clays of the Tuscaloosa are exposed. One of the best of these exposures is in Stewart's Cut a mile east of Glen Allen. The section here is as follows;

(*k*) *Section in Stewart's Cut, near Glen Allen, Marion Co.*

1. Gray laminated clays with fine leaf impressions.....25 feet.
2. Crust of limonite of variable thickness and irregular horizon ..... 1 foot.
3. Cross-bedded sands, yellow and pink colors.....25 feet.

The plant remains are well preserved and easily gotten out, and a large collection was made here by Prof. Ward and myself. While this collection has not yet been fully studied, a number of the species have been identified and are given in the list below. Between Glen Allen and Gold Mine, and again between the latter place and Haley's and probably at other points are tracts known as "flatwoods," the immediate basis of which is a gray clay becoming red at the surface; below the clay at no great depth lie the sandstones and other rocks of tne Coal Measures. The timber of the "flatwoods" is chiefly post oak, with some

Spanish oak and short leaf pine. In these flatwoods are depressions like lime-sinks in which water stands at most seasons of the year. The two tracts above specified are some four or ffve miles square.

In townships nine and ten, range 12 west, occurs a white clay, indurated into a mass breaking with conchoidal fracture. This clay may be seen at several points about Chalk Bluff to which it has given the name. It is a member of the Tuscaloosa formation, and will undoubtedly some day be fully utilized. (For analysis see below—Useful Materials.)

About Pikeville also are many occurrences of the various clays characterizing the Tuscaloosa. Among the pebbles, we find in this county as elsewhere the angular chert pebbles as well as well rounded quartz pebbles and in one or two places they may be seen in such relations as to fix their relative horizons. At Gold Mine on the head waters of New River, and at the crossing of Buttahatchee near Haley's there is an abundance of large well rounded quartz pebbles, some having a longer dimension of five or six inches. At the former locality it seems to be well established that many years ago a small amount of gold was washed out from the gravel and sands. The same may be said of the gravel and sands about Fayette Court House. In the vicinity of Haley's we may see a section of what I interpret to be both the Lafayette and the Tuscaloosa formations in direct contact. Here there is a bed of red loam with its well rounded, iron stained pebbles of quartz, eight or ten feet in thickness, overlying a bed of angular chert pebbles associated with an irregular bed of indurated white clayey sand of Tuscaloosa age.

The two sorts, both of pebbles and associated sands, are quite distinct; the upper being identical with what may be seen all over the lower part of the state as far as the Gulf, while the latter I have never seen far removed from the belt of country in which occur exposures of undoubted Tucaloosa

beds. Between Haley's and Chalk Bluff and also south of the latter place, are ridges as much as 275 to 300 feet high above the neighboring watercourses, over which large angular pebbles of chert lie strewn covering everything, on the summits and for some distance down the sides. These ridges support a growth of mountain oaks, white oaks, post oaks, and chestnut trees with very little pine. In places at the base of these hills are the bold clear springs breaking out amongst the gravel and recalling the limestone springs of the Subcarboniferous formation. On the road between Pikeville and Gold Mine, the hills are generally covered with angular chert pebbles, but near the crossing of some of the headwaters of New River are large rounded pebbles of quartz. Above Gold Mine, between Gold Mine and Pikeville and west of the latter place, the sands and pebbles are cemented by iron into a firm hard conglomerate that is used for millstones. This rock crops out a certain level along the hillsides; it is not a regular stratum but occurs in interrupted masses, and its materials seem to be of Tuscaloosa age. North and Northwest of Pikeville the angular pebbles occur pretty generally up to the heights of 175 or 180 feet above the watercourses. Above that are sands chiefly, in places indurated by iron into plates and blocks of ferruginous sandstone.

FRANKLIN AND COLBERT COUNTIES AND ADJACENT PARTS OF MISSISSIPPI.—The materials of the Tuscaloosa formation are spread over the western parts of these two counties and consist in great part of angular chert gravel which is often cemented into a firm breccia or conglomerate by iron oxide. As a rule, upon the highest parts of the land the surface is chiefly of sands, the pebbles being covered with a varying thickness of these sands which crop out at lower altitudes up to 175 feet or so above the watercourses. Beds of clay of fine quality are met with in many places among the

Tuscaloosa beds, and in some localities they have been utilized.

Samples of the clay of the Tuscaloosa formation have been collected by Dr. George Little for the Survey, at many places of Tuscaloosa, Pickens, Lamar, Fayette, Marion, Franklin, Colbert, Lauderdale, and in Ittawamba county in Mississippi. These will be more particularly mentioned in another place. (Useful Materials.)

In 1884 Mr. Johnson, on his reconnaissance of Tishomingo and Itawamba counties, in Mississippi, saw beds of lignite and tough, laminated clays which he, at the time, referred to a formation below the Eutaw (our Tuscaloosa). This lignite was traced by him the whole length of Reed's Creek (between the Tombigbee at Fulton and Bull Mountain creek). At several localities, viz., at Maxey's Old Mill, Sec. 9, T. 10 S., R. 9 E., he collected many fine leaf impressions. The lignite here was two feet thick. At Reed's Mill and at Chaney's, Secs. 20 and 17, in T. 10 S., R. 9 E., many phytogene fossils were collected, and these localities were remarable for the fine, jet-like appearance of the lignite. A jet of this kind was also found by Mr. Langdon in Centerville, Bibb county, Alabama. At Barnard's Bluff on the Tombigbee, the lignite appears again embedded in characteristic clays of the Tuscaloosa formation.

Mr. Johnson also calls attention to the gravel beds which occur in this part of Mississippi, and which, according to my observations, have their counterpart in Marion, Colbert, and Franklin counties, Alabama. The materials of these gravel beds are mostly cherty, subangular, and quite different from the usual quartz pebbles of the Lafayette. Associated with these are the so-called kaolin beds and the deposits of pulverulent silica. The pebbles as well as the silica are evidently derived for the most part, if not entirely, from the fossiliferous chert of the Subcarboniferous formations of that region. Mr. Johnson expresses the opinion that

these pebble beds of chert underlie the newer, stratified Lafayette, without being a part of the same.* Whenever the pebble beds occur in the Cretaceous or sub-Cretaceous clays of Tishomingo and Itawamba counties, in Mississippi, there is a prevalence of these cherty characteristics. In this connection we may also refer to the fact that the pebbles seen in the Tuscaloosa sands at White's Bluff and at Steele's Bluff on the Tuscaloosa were of chert and not of quartz.

In Bibb, Perry, Chilton, and Autauga Counties.—Between Tuscaloosa and Scottsville, and north of this line up nearly to Blocton the clays and sands of this formation overlie the older formations in irregular patches left as remnants of a once universal covering which has since in great part been removed. Between Scottsville and Centerville, the Tuscaloosa clays and sands appear at many points overlying the strata of Silurian and Carboniferous ages. The hill in the eastern part of Centerville contains a good deal of the red and mottled clays of the Tuscaloosa formation. Three and a half miles east of south of the town, in digging a well some fragments of lignite of jet-like aspect were brought out. Dr. Phillips has analyzed this material for me with the following results:

Jet-like Lignite, Tuscaloosa Formation, Bibb County.

PROXIMATE ANALYSIS.

Moisture	11.90
Volatile combustible matters	52.70
Fixed carbon	34.90
Ash	0.50
Total	100.00

Sulphur.....1.18.

*This opinion is confirmed by several sections given by me above, where the gravels of the two formations can be seen in direct contact.—E. A. S.

ULTIMATE ANALYSIS.

Carbon	42.82
Hydrogen	6.01
Oxygen (by difference)	37.29
Nitrogen	0.80
Sulphur	1.18
Ash	0.50
Moisture	11.90
Total	100.00

Some distance further down the road from Centerville to Selma, Mr. Langdon describes the following section:

(*l*) *Section south of Centerville on Selma road.*

1. Red loam and pebbles, Lafayette.....2 feet.
2. Purple and red mottled clays.....½ foot.
3. Coarse cross-bedded sands.....20 feet.
4. Sand interstratified with gray laminated clay.....8 feet.
5. Gray laminated clay.....6 feet.
6. Dark red sand with laminæ of gray clay.....4 feet.

On the School House hill in the eastern part of Centerville, we find a capping of the red loam and pebbles of the Lafayette, under which a purple clay about four feet thick and under that still, purple and yellowish mottled clays some ten feet in thickness.

Between four and five miles from Centerville on the Randolph road we have the following sections:

(*m*) *Section 4 to 5 miles east of Centerville, Bibb County.*

1. Gray and reddish, sandy clays.....15 feet.
2. Ledge of sandstone showing cross bedding.....3 feet.
3. Whitish sands and clays.....4 feet.
4. Nearly white, cross bedded sands.....25 to 30 feet.

These materials occur at intervals along this road as far as Soap Hill some seven miles from Centerville where the following section is exposed:

(*n*) *Section at Soap Hill, 7 miles east of Centerville, Bibb County.*

1. Purple, mottled clays at summit of hill..... ....5 feet.
2. Clayey sands in several ledges .....10 feet.
3. Cross bedded, yellowish and whitish sands, traversed at intervals by ledges of sandstone formed by the induration of the cross bedded sands.....30 feet.
   The thickest of the above sandstone ledges is about 3 feet.
4. Laminated, gray clays, with partings of sand.....10 feet.
5. Alternations of laminated, gray clays and cross bedded sands in beds of 12 to 18 inches thickness.....40 feet.
6. Yellowish, cross bedded sands, with clay partings.....20 feet.
7. Laminated, gray, sandy clays, containing a few leaf impressions, which are, however, not distinct enough as a rule to permit perfect identification.....10 to 15 feet.
8. Grayish white sands.....8 feet.

In this section the first three members are best seen on the eastern slope of the hill and Nos. 7 and 8 in a gully on the eastern side of the hill. The intervening members are most clearly exposed on the western descent of the hill, nearly a mile from the first locality.

The town of Randolph is upon a ridge capped with the pebbles and red loam of the Lafayette, below which a bed five feet or more in thickness underlaid by 15 feet of cross-bedded sands. These strata are seen at many points on the Randolph and Pratt's Ferry road northwest of the former place: thus, three-fourths of a mile from Randolph, on this road, we see red and gray mottled clay five feet thick, overlying beds of purple and gray coarse-grained cross-bedded sands, slightly micaceous. At other places where the cuts are deeper, we find below these sands a gray laminated clay. Half a mile north of the intersection of this road with the Centerville and Montevallo road Mr. Langdon gives the following:

(*o*) *Section Northeast of Centerville.*

1. Red loam, etc., Lafayette.....3 feet.
2. Laminæ of gray clay in red loam.....6 feet.

3. Red sand and gray laminated clay.....4 feet.
4. Cross bedded white and yellow sands.....4 feet.
5. Gray laminated clay.....8 feet.

Mr. Langdon's notes supply us also with some information concerning the country lying to the southwest, south, and southeast of Centerville, in which the Tuscaloosa strata occur. In townships 21 and 22, ranges 7 and 8, many of the ridges are composed of purple clays 8 to 10 feet in thickness resting on 4 to 6 feet of gray clay, itself overlying 20 to 25 feet of cross-bedded sands. The summits of the ridges are often protected by plates and crusts of ferruginous sandstone which occasionally becomes a fairly good limonite, as in the vicinity of Ironville. On the divide between the waters of the Cahaba river and Oakmulgee creek, in Townships 21 and 22, Ranges 9 and 10 are numerous high hills capped with this iron crust sometimes 15 inches in thickness, fragments of which strew the hillsides for many feet below the summit. On one of these hills 10 miles east of south of Centerville, 60 feet below the summit, a bed of 12 feet thickness of pure white, slightly micaceous and argillaceous sand, was seen, and 40 feet below the sands the usual mottled clay.

East of Oakmulgee creek, in S. 1, T. 20, R. 10, Mr. Langdon gives the following:

(*p*) *Section East of Oakmulgee Creek, Bibb County.*

1. Red loam containing limonite plates and specks of white clay, 20 feet.
2. Mottled clay, purple and gray.....3 feet.
3. White sand containing numbers of small white angular pebbles, 2 feet.
4. Mottled clay, purple gray and yellow, merging gradually into the next succeeding bed.....4 feet.
5. Yellow micaceous sand; where exposed the surface becomes indurated into sandstone, the cement being limonite.....2 feet.

Perryville is near the border of the Tuscaloosa and Eutaw formations, the hills immediately about the place being prob-

ably mostly of Eutaw materials, but on the road to Jones's Switch the Tuscaloosa beds make their appearance and we have several instructive sections in that vicinity near Vinehill, in Autauga county.

(*q*) *Section near Col. J. W. Lapsley's, near Vineton, Autauga County, No. 1.*

1. Stratified clays of white, pink, and purple colors, interlaminated with thin sheets of yellow sands; the lower 8 feet of this bed have a larger proportion of sands.....10½ feet.
2. Gray, laminated clays, with partings of purple sands .....5 feet.
3. Yellowish white, laminated clays, with purple and other bright colors on the dividing planes, 5 feet showing; but the same beds appear to continue down the hill for at least 10 feet farther, 15 feet.

At another locality near Colonel Lapsley's, in a gully, we see the following section:

(*r*) *Section near Col. J. W. Lapsley's, No. 2.*

1. Yellowish sands, beautifully cross bedded..... .....4 feet.
2. White and pink clays, interbedded with yellow sands.....10 feet.

Along the road leading from Colonel Lapsley's to the railroad station (Jones's switch), we get another section of the strata represented in the first section above, together with some underlying beds. In the upper part, these beds, being exposed along a road, are much stained, so that it is impossible to correlate them, foot by foot, with those exposed in Section 1, although the two have about the same altitude and are distant from each other only about half a mile.

Below some 40 or 50 feet of red loam containing fragments and bowlders of ferruginous sandstone, such as characterizes the Lafayette formation, we get the following section:

(*s*) *Section near Col. J. W. Laysley's, No. 3.*

1. Purple clays, interbedded with reddish sands.....6 feet.
2. Mottled (red and yellow), sandy clays, partly obscured by overlying pebbles, and sands.....12 feet.

3. Red sands, containing small, lenticular bits of yellow clay, 5 feet.
4. White and yellow laminated clays.....6 to 8 feet.
5. Strata not seen.....10 to 15 feet.
6. Variegated, micaceous, and slightly argillaceous sands, strongly cross bedded; colors, bright and sharply defined, pink, dark purple, yellow, and red.....5 to 6 feet.

The strata of bed No. 6 are identical in appearance and in composition with the variegated sands exposed in the gullies at Mr. Avery's, near Havana, in Hale county, above described. I did not notice here the yellow sands with pebbles immediately over the variegated sands, but they may have been in the division No. 5, here obscured by surface materials.

Across a small ravine from this section, the yellow sandy clays have been washed for yellow ocher, the beds occupying about the same position as Nos. 2, 3, and 4 of the preceding:

(*t*) *Section at the ocher beds, near Vineton.*

1. Yellowish red, cross bedded sands, inclosing thin streaks of purple clay.....6 feet.
2. Yellow, sandy clay, from which the ocher is obtained....16 feet.

The sand makes about 80 per cent. of the above bed, and the ocher is obtained from it by washing. The ocher is of excellent quality and of bright yellow color.

Nearly 100 feet below the lowest of the beds of Section 3 we see in the banks of Mulberry Creek, just below the iron bridge, the following section:

(*u*) *Section on Mulberry Creek, near Vineton, Autauga County.*

1. Mottled, purple clays, similar to those at Steele's Bluff, on Tuscaloosa River.....5 feet.
2. Yellow, cross bedded sands.....2 feet.
3. Mottled clays, sandy below.....5 feet.
4. Grayish white, micaceous sands, with irregular patches of red and yellow colors.....4 feet to water.

This whole section is identical in appearance with that seen at White's Bluff and at Steele's Bluff.

From Vineton up to Randolph very little can be seen of the strata of the Tuscaloosa formation until within three miles of the latter place, where the dark purplish gray clays, which seem to lie near the base of the formation, are encountered. These clays are undistinguishable from those above described between the two branches of Sandy Creek in Tuscaloosa county.

Through the lower part of Chilton and the upper part of Autauga, the watershed between the Coosa and the Alabama is in great part made up of the clays and sands of the Tuscaloosa formation with a covering of the pebbles and red loam of the Lafayette. At many points along the line of the M. T, & M. R. R. in Autauga, west of Kingston, and upon the watershed above noted, the purple clays are exposed in washes and gullies in the forests of long leaf pine. These red clays are seen within five or six miles of Prattville towerds the north.

From Vinehill to Prattville the prevailing soils are brown or dark red sandy loams, often quite coarse in grain, resting upon a firm yellow or reddish clayey subsoil. Sometimes a coarse red sand is found to depths of many feet before the clay is reached. In most places the growth is long leaf pine, with turkey and black jack oaks, small post oaks, and in some places high ground willow oak. Upon some of the higher summits where the surface is covered with the plates and crusts of ferruginous sandstone, very little else than long leaf pine grows, and this is usually stunted. It is difficult to imagine more desolate scenery. Pebbles on this road are seen only in the depressions formed by the larger streams, not upon the summits between them, and as a rule they seem to be chiefly confined to the eastern (left) banks of these streams. This is the case at least with Little Mulberry and Swift creeks. A few pebbles were seen on the western side of Autauga creek, but the great bulk of them were encountered on the eastern side. From Booth's bridge

down to Prattville, the way lies along the eastern side of this creek and pebbles are abundant the whole distance. Pebbles are also abundant on the hills on the western side within five miles of Prattville and perhaps higher up the creek. In going down towards most of the streams along this road fairly good sections of the red clays and sands of the Tuscaloosa are to be seen. The pebbles may belong in part to the Tuscaloosa formation. but are certainly in part of Lafayette age. It is at times impossible to discriminate between the two.

BETWEEN MONTGOMERY AND COLUMBUS, GA.—Along the road from Prattville to Notasulga, via Wetumpka and Tallassee, I saw no exposure of recognizable Tuscaloosa beds.* Further south, however, in Montgomery and Macon counties, such exposures are seen at many places.

Near Cowles Station on the Montgomery & West Point R. R., close to the site of Old Fort Decatur, Mr. Langdon gives the following section as exposed in the railroad cut and down the bluff of the river.

(r) *Section at Old Fort Decatur, near Cowles' Station, Macon County.*

1. Red loam and pebbles.. .....10 feet.
2. Mottled purple and light green argillaceous sand.....6 feet.
3. Purple and greenish sands more argillaceous than the foregoing, and presenting a banded appearance; merges gradually into the following .....5 feet.
4. Strongly cross-bedded coarse grained micaceous sand, containing some large brown pebbles and bits of green sandy clay. Along the lines of cross-bedding there are occasional streaks of dark brown color probably of organic origin. The sand is light green when wet .....20 feet.
5. Finer grained light greenish sand with no pebbles, much mica and no clay, although the sand is decidedly argillaceous, 10 feet.
6. Coarser grained cross-bedded sands with pebbles and a few lenticular masses of mottled sandy clay extending to the water's edge and probably considerably below that level.....20 feet.

* In the summer of 1894, I observed in the banks of a small stream nearly opposite the Penitentiary buildings a very characteristic outcrop of Tuscaloosa strata. Below Wetumpka also, along the Buck's Bridge road, there are a few outcrops that may be assigned to the same formation.

Mr. Langdon remarks upon the circumstance that the character of the beds varies very decidedly in a horizontal direction, thus a bed of coarse sand and pebbles will in a hundred yards be changed into a mottled sandy clay and the transition will be so gradual as to be almost imperceptible from step to step.

From Notasulga to Society Hill the first appearance of the Tuscaloosa beds (purple clays), is near Farrell's Mill, S. 30, T. 18, R. 25 E., and these beds interstratified with sands and pebbles, make the country then out to the Columbus road at Society Hill. The characteristic growth upon these gravelly pine hills is long leaf pine, black jack, turkey and high ground willow oaks. At Society Hill coarse grained cross-bedded sands include a bed of red, white, and mottled massive clay. The cross-bedded sands appear again 2 miles east of the place, with strings of subangular pebbles of irregular shape and bedding included. About Marvyn similar cross-bedded sands with strings of pebbles, about 10 feet in thickness, overlie about the same thickness of mottled clays. East of Crawford, we see the same pebbly sands and mottled clays. On the east side of Little Uchee creek at several points the feldspathic sands are indurated into a tolerably firm sandstone. Beyond Little Uchee a ridge 200 feet or more overlooks the river valley. Descending this towards Phœnix City and Columbus, we pass over a series of Tuscaloosa beds the whole distance of 200 feet vertical. These strata are cross-bedded red, and mottled sands, and red and purple mottled clays, the sands very greatly predominating.

Near the bridge over the creek separating Phœnix City from Girard (Girard creek), Second Bottom or River terrace deposits are seen to rest in places directly upon the decayed gneiss, but in other places there comes in a variable thickness of Tuscaloosa mottled clays between the two.

The soil of most of the country between Society Hill and

Columbus is a gray or lead colored sandy loam, usually rather poor, and with great quantities of pebbles below the subsoil. Beds of sand are numerous and deep on both sides of the many branches and creeks tributary to the Uchees. It is quite possible that some of this sandy and pebbly material may belong to the Lafayette, but the undoubted Tuscaloosa beds seen are quite competent to furnish it all.

Just south of Girard in railroad cuts and washes we see numerous good sections of Tuscaloosa beds consisting of coarse grained cross-bedded sands, gray, white and yellow, spotted with purple. In the upper parts of these beds are pockets and strings of subangular quartz pebbles, usually easily distinguished from the well rounded pebbles of the overlying Lafayette. Going south from Girard we very soon pass out of the region of the Tuscaloosa sands and clays into gray laminated clays interstratified with calcareous beds —probably of the Eutaw.

From the above notes it will appear that the surface extent of the Tuscaloosa outcrop east of Montgomery is much less than in the western part of the state. Thus Cowles' Station is not far from the southern line of these beds and they were not seen at all in the latitude of Tallassee. From Farrell's Mill to Society Hill which cannot be far from the lower edge of the belt, we have a width of not many miles, ten probably at most. The lower or southern edge of the Tuscaloosa is only a few miles below Columbus or Girard, I have no notes of its extent to the northward of these cities. I have seen little or no evidence of the overlapping of the Tuscaloosa beds upon the Crystalline rocks far inland from the main body of the Tuscaloosa, while in the vicinity of Woodstock such outlying masses are to be seen some thirty miles from the main body of the formation at Tuscaloosa.

(3.) ECONOMIC MATERIALS OF THE TUSCALOOSA.

Clays.—The materials of this formation which are destined to become of great commercial importance in the future, are the clays which occur at intervals throughout it. These are in all respects similar to the clays of New Jersey which belong to the same geological horizon. At several places in the state, use has been made of these clays in the manufacture of ordinary stone ware, and lately in the manufacture of fire brick, but a beginning has hardly yet been made to their development. We have given in the preceding pages many notes of their occurrence and quality, and in the absence of numerous analyses and practical tests, perhaps that is about as much as need be said concerning them.

While the clays occur throughout this formation, they are more abundant perhaps in the region lying to the west and northwest of Tuscaloosa in Pickens, Lamar, Marion, Fayette, Franklin and Colbert counties. A preliminary examination of this region was made for the Survey by Dr. George Little, with the result of finding a number of localities from which the clays may easily be mined and the products shipped. We have as yet few chemical analyses, but Dr. Phillips has made a number of tests for fusibility, which show that our Tuscaloosa clays in many cases are about as refractory as the Mount Savage material.

At Woodstock and below Bibbville on the A. G. S. road these clays are gotten up and shipped to Bessemer for mixing with the imported material.

At Bibbville a fire brick is made of material gotten in the near vicinity. About Tuscaloosa the Messrs. Cribbs have for many years used the clay in the manufacture of stone ware. Near Fayette Court House is a bed of nearly white plastic clay several feet thick; at Shirley's Mill, a few miles south of the Court House, a gray clay ten or fifteen feet thick and filled with leaf impressions is known. At Glen

Allen on the Kansas City road, there is a cut in which fifteen or twenty feet thickness of a brown clay is exposed which is also filled with leaf impressions.

Above Pikeville, at Chalk Bluff, there is a bluff where some ten feet thickness of a white stony clay is exposed. This has been analyzed with the result given below.

Clay from Chalk Bluff, Marion County.

Silica	47.20
Alumina	37.76
Ferric oxide	.91
Lime, potash, etc	traces.
Water	14.24

This is close in composition to pure kaolin.

A white clay used by Mr. Cribbs at Tuscaloosa has the following composition:

White plastic clay, Tuscaloosa, Ala.

Silica	62.25
Alumina	27.90
Lime	2.36
Ferric oxide	0.10
Loss at red heat	10.00

It is the intention to make this the subject of a special bulletin, in which we hope to give specific details of the tests made upon the clays as well as a sufficient number of analyses to show forth their chemical relations; at this time we wish only to direct attention to this most inviting field.

(4.) PALEONTOLOGY OF THE TUSCALOOSA FORMATION.

The collections from this formation have been made by Prof. W. M. Fontaine, Prof. Lester F. Ward and myself. They have passed into the hands of Prof. Ward for final study. At my request Prof. Ward has sent notes concerning these collections which are given below.

"The collections have not yet been properly worked up,

but they have been carefully compared with all the similar floras that have been published, and many of the specimens have been provisionally named. The names I will give you are not always perfectly reliable, but may be used for any rough purposes. The comparisons are all with the floras of the Amboy clays, the Dakota group, and the Cretaceous of Greenland, some of the species being common to all these floras, and some occurring in only one. The greater number are Amboy clay types according to Dr. Newberry's latest determinations, the specimens having been compared either directly with his named fossils or else with his figures as he left them, which will soon be published.

"Wherever Heer is the authority the plants were first found in Greenland and have been identified in the Amboy clays. Where Lesquereux is the authority the plants belong to the Dakota Group. Where Newberry or Hollick is the authority, they are Amboy clay types. A few are old established forms from the European Cretaceous. The following is a list of all that could be identified specifically:"

Plants of the Tuscaloosa Formation.

	LOCALITIES.					
	Cottondale.	Roads west Tuscaloosa.	Shirley's Mill.	Glen Allen.	Snow's Place.	
Andromeda latifolia Newb	*	*	*	*	*	
Andromeda Novæ-Calcareæ Hollick			*	*		
Andromeda Parlatorii Heer	*		*	*		
Aralia Wellingtoniana Lesqx	*					
Carpolithus floribundus Newb			*			
Celastrophyllum crenatum Heer	*					
" undulatum				*	*	
Cinnamomum intermedium Newb	*			*		
Cladophlebis parva Font					*	
Cycadinocarpus circularis Newb				*		
Czekanowskia capillaris Newb			*			
Dewalkia Groenlandica Heer			*			
Diospyrus primæva Heer			*	*		
Eucalyptus attenuata Newb		*			*	
" nervosa "		*				
" parvifolia "					*	
Ficus inæqualis Lesqx	*		*			
" lanceolato-acuminata Newb			*			
" Woolsoni Newb	*					
Liriodendropsis angustifolia Newb			*			
" simplex Newb			*	*		
Magnolia alternans Heer	*					
" auriculata Newb	*		*	*		
" glaucoides Newb			*			
" longifolia Newb			*			
" speciosa Heer			*			
Myrsine borealis Heer	*		*		*	
Populus apiculata Newb	*					
Proteoides daphnogenoides Heer	*		*	*	*	
Pterospermites modestus Lesqx	*					
Tricalycites papyraceus Newb			*	*	*	
Widdringtonites Reichii (Ett) Heer			*			
Sequoia gracillima (Lx) Newb					*	
" heterophylla Vel					*	
" Reichenbachii (Gein.) Heer					*	

Soils and Agricultural Features of the Cretaceous.

From the divisions of the Cretaceous formation as above marked out and their constituent strata the soils derived

from their disintegration are not difficult to classify in their main features.

Tuscaloosa.—At the base of the formation we have the sands and clays of the Tuscaloosa formation usually if not always devoid of lime. The sands are generally thoroughly leached and a reddish or yellowish color is eminently characteristic. In some sections these sands are mixed with scales of mica, and in the upper part of the formation they have a bright pink or light purple color. Pebble beds are also sparingly distributed through the formation. To these characters add the circumstance that the territory of the Tuscaloosa has had a mantle of pebbles and sands of another formation spread over it (the Lafayette), in many respects scarcely to be discriminated from the materials proper to the Tuscaloosa itself, and we have the key to the agricultural features. The soils are almost without exception sandy or loamy, the limited areas in which the clays prevail being hardly worth mentioning. From about Tuscaloosa eastward to the Georgia line along the belt formed by the Tuscaloosa, is a region of long leaf pine forests, with the varieties of oaks determined by the degree of sandiness of the soil. In the one extreme we have the barren sands with timber of long leaf pine, black jack, turkey, and upland willow oaks, to these come the post oak with slight amelioration, and with increasing proportion of loam, the Spanish, red, and black oak sand hickory, with white oaks, sweet gums, sour gums and poplars, in the lower places. To the northwestward of Tuscaloosa the long leaf pine is not found in any great quantity, but the short leaf species takes its place. This corresponds in the main with Gravelly Pine Hills of our Agricultural report of 1881–2.

Eutaw.—Next above the Tuscaloosa come the somewhat similar strata of the Eutaw, differing from the former mainly in the more general occurrence of thin sheets of gray clay along the lines of stratification of the prevalent sands. This cir-

cumstance conjoined with the fact that greensands are not by any means uncommon in this formation make the soils of the Eutaw as a body easily distinguishable from those of the Tuscaloosa.

The Eutaw soils in general may be characterised as loams varying from sandy to clayey; they are usually of yellowish to red color, and in some respects resemble the typical red loam of the Lafayette, but they are often more clayey than these, and they pack readily under the wheels of vehicles as they dry out, into material that very strongly simulates the post oak soils to be spoken of below. The characteristic timber is post, black and Spanish oaks, hickory and poplar, but short leaf pine is associated with these wherever the sands are somewhat prevalent. This terrace like all others in the Coastal Plain has had its mantle of Lafayette sands and loams, and these form the soils upon most of the ridges and divides, and in addition modify the soils of the Eutaw proper where washed down upon them. Upon the Lafayette soils the long leaf pine flourishes as upon no other, so that patches of long leaf pine and its associates intersperse the forest growth above specified. The yellowish clayey soils of the Eutaw find no analogue among the sandy loams of the Tuscaloosa territory, although as a matter of course, its more sandy soils are sometimes difficult to distinguish from almost identical products of the latter.

The soils of both these divisions of the Cretaceous are easily tilled, and where protected from washing are fairly productive. The Eutaw soils in the main are superior to those of the Tuscaloosa.

Rotten Limestone.—The black prairie or canebrake soils overlie the Rotten Limestone division of the Cretaceous, which is a clayey limestone or chalky marl stone of tolerably uniform composition. From the great thickness of this formation, over one thousand feet, it underlies a wide belt of

country extending from Mississippi to the central part of Macon county, Alabama, its place being then taken by the Blue marl to be described below.

Throughout the whole of this region the overlying Lafayette beds covering it, have been more or less completely removed by erosion but patches of them are left in places, chiefly upon the divides and along slopes, and these play an important part in the production of soil varieties.

(1.) Where the limestone or chalk lies at the surface it yields on disintegration, a gray or greenish gray, clayey calcareous soil, which becomes black or very dark colored when mixed with vegetable matters. The subsoil of the cultivated lands is usually of a lighter color than the top soil, and passes gradually into the lime rock at varying depths.

Where the depth of soil is sufficiently great it supports a varied growth of trees, among which the following are characteristic: red cedar, pin oak, nutmeg hickory, pecan, chinquepin oak, along with post, red, and black jack oaks. From slight elevations throughout this region the soil is often washed away, leaving the bare spots of the limestone, or spots where the soil is exceedingly thin, "bald prairies," with characteristic growth of clumps of crab apple, wild plum, honey locust, and persimmon. Notwithstanding the heavy clayey nature of these soils they crumble readily upon drying because of the lime which they always contain, hence with proper drainage they are much more easily cultivated than would be thought possible upon inspection of them when thoroughly saturated with moisture.

(2.) While the surface loams of the Lafayette have as a rule been very generally removed from the Rotten Limestone territory, there are many places where they still remain upon the sandy ridges and brown loam table lands which so agreeably relieve the monotony of the prairie region. These superficial beds give rise to a variety of soils which upon many of the ridges do not differ from similar loam soils

of other localities being formed of the same materials, and which range from extremely poor sandy soils to fertile brown loams.

(3.) Where this surface loam is mingled with the soils derived from the disintegration of the Rotten Limestone, as is often the case near the bases of the sandy ridges above mentioned, and in the shallow depressions in the limestone, yellow or mulatto soils, with a characteristic growth of post oaks are produced. From this they are often spoken of as "post oak prairies." With the post oak, are associated the short leaf pine, some black jack, and other oaks, with occasional hickory. The long moss drapes all these trees as a rule.

The post oak prairie soils are mostly rather stiff, calcareous clayey loams of yellowish to reddish color, having a subsoil of red or yellow clay which sometimes becomes more sandy with increasing depth, but more often retains much the same character down to the unchanged limestone rock, ten to twenty feet.

(4.) The bottom soils of this region vary between wide limits from a stiff black prairie soil, formed by the washings of the black prairie soil, to light rather sandy loams, which have usually lime enough in them to make them strong and lasting.

(5.) Along the northern border of this belt a bed of highly phosphatic greensand comes to the surface, and gives rise to some of the most fertile lands of this section. They are usually sandy being in part also derived from the sandy beds of the underlying Eutaw, but they are of exceptional fertility. The sloughs which receive the washings from the greensand marls, are the richest spots in the State. A mere inspection of the crops and weeds growing upon them ought to convince the most skeptical of the fertilizing qualities of the marls. Along the southern margin also of the prairie region a similar greensand marl out crops with results entirely simlar to those above described.

Ripley.—Immediately to the south of the low trough of the Canebrake region we come upon a region whose soils are derived from the uppermost of the divisions of the Cretaceous, viz: the Ripley.

In the width of the surface outcrop and in the nature of the topography and soils, the Ripley in Alabama shows two somewhat divergent types. Westward of the meridian of Montgomery, this formation occupies a belt which will not average more than five or six miles in width; eastward of that meridian however, it widens out to more than thirty miles from north to south.* In the western part there is a greater proportion of indurated strata, and this is reflected in the broken topography of the Hill Prairies or Lime Hills. Towards the east on the other hand, the loose micaceous and calcareous sands, and beds of clay prevail and the much more even surface of the Blue Marl Lands is the result. These two divisions may best be described separately.

Hill Prairies.—In the western part of the State the Ripley strata consist of hard sandy crystalline limestones, and indurated ledges of calcareous sands, interstratified with loose bluish micaceous sands and calcareous clays. This disposition of the strata gives rise to the characteristic topography of the limy prairie hills. The softer clays and sands are easily washed away, and the harder strata thus undermined break with perpendicular faces, making very steep slopes to the resulting hills. Upon the uneroded divides between the streams we find remnants of the once universal mantle of pebbles, sands, and red loam of the Lafayette, and where the divides are broad they are level plateaus with brown loam soils timbered with Spanish, post, and red oaks and black jacks, with short leaf pine upon the better spots and long leaf pine and its associates where the proportion of sandy materials in the soils increases. Of course these soils have nothing to do with the Ripley, and are of precisely the same character over all the other for-

*For details of the distribution of these beds—consult the map, plate XVI, and remarks above.

mations of the Coastal Plain. The thickness of these surface materials varies from 25 feet down. These ridges and plateaus break off towards the black prairies of the Rotten Limestone in a series of steep rugged hills, along the slopes of which the limy clays are encountered soon after the summits are left. The soils are then are yellowish tenacious clayey loams with timber consisting of short leaf pine, red, post, and Spanish oaks, hickory, ash, poplar, etc., all draped with long moss. In many places the hill sides are bare of vegetation and deeply gashed with gullies, and in these bare spots the surface is often strewn with oyster shells washed out of the strata. At certain stages of drying these clays acquire an extraordinary degree of tenacity, and so clog the wheels of vehicles as to render travel almost impossible.

From what has been said it will be evident that there is in this region ample opportunity for the formation of intermediate varieties of soils resulting from admixtures of the Lafayette materials with those derived directly from the Ripley. The heavy clays of the latter, tempered with the sandy loams of the former produce one variety of post oak prairies, i. e. somewhat clayey lands with reddish or yellowish soils on which the post oak is the prevailing tree. In some sections of the Ripley area, we find a great thickness of yellowish micaceous sands with somewhat indurated ledges running through them, and with comparatively little clay or lime. These yellow sandy hills with much short leaf pine are quite characteristic of the very topmost of the Ripley, and make a narrow belt along its southernmost border, as for instance, just north of Snow Hill in Wilcox and south of Dayton in Marengo, and between Livingston and the Flatwoods in Sumter county.

Blue Marl Lands.—East of the Montgomery meridian a bluish sandy micaceous material with a considerable percentage of lime, is very widely distributed. This has the common name of blue marl, and it lies interstratified with beds of massive clay containing often a large amount of

lime, sometimes in the form of white concretionary masses. To the east and southeast of the Chunnenugga Ridge (to be more particularly described below,) the lands made by this blue marl are somewhat undulating, but not broken. The resulting soil from their disintegration is sandy, but with enough of lime to make it generally very fertile, in fact far more fertile than its appearance would indicate. In these lands there are tracts of soil derived from the massive clays above spoken of, and when they are deficient in lime they make the so called "hog-wallow" prairies. With greater proportion of lime these clayey soils resemble very closely some of the post oak prairies spoken of above. Over this region also, the Lafayette has once formed a universal covering, and its sands and loams washed down from the hills and divides and mingled with the sands and clays of the Ripley produce a variety of mixtures. Along the Cowikee creeks and Bear Creek we find all the varieties resulting from these admixtures as well as from the disintegration of the Ripley materials alone, which in themselves range from sands to heavy joint clays. Where the surface mantle of the Lafayette is not too thick the vegetation shows the effect of the lime in the underlying Cretaceous formation, and long moss drapes all the trees.

Chunnenugga Ridge.—Along the southern border of the Blue Marl lands there is a belt of somewhat rugged sandy hills similar to those mentioned north of Snow Hill, and where the Ripley here borders on the territory of the Rotten Limestone we find also in eastern Alabama somthing approaching the characters of the Lime Hills. This is seen in the Chunnenugga Ridge, which under that name extends through Bullock County forming the watershed between the Chattahoochee and other streams flowing more directly into the Gulf on the one hand, and those flowing into the Alabama river on the other.

This ridge without, however, the specific name, extends up into Macon and Russell on the east and through Montgomery on the west, beyond which it merges into the Hill

Prairies above described. Through all this distance it overlooks the low trough of the black prairies of the Rotten Limestone towards the north with somewhat precipitous slopes in that direction, while its descent towards the south is much more gentle. The Chunnenuggee Ridge is made in great part by alternations of hard limestone ledges and bands of indurated sands of the Ripley, over which is the usual mantle of Lafayette sands, pebbles and loam. On the ridge proper, therefore, the soils are sandy or loamy and depend upon the Lafayette alone. Along the slopes of the ridge and especially the northern slope, the calcareous beds of the Ripley and of the Rotten Limestone are soon reached in descent, yielding the usual hill prairie and black prairie soils. Going southward from the summit of the ridge, the Ripley strata are also encountered wherever the overlying Lafayette has been cut through by erosion, but the transition in this direction is not by any means so abrupt.

Undulations and Displacements in the Cretaceous Strata.

The Rotten Limestone or Chalk division of the Alabama Cretaceous consists of about one thousand feet of calcareous strata of very great uniformity of lithologic character throughout. The strata of the Eutaw division are cross-bedded sands and laminated clays, possessing no very well marked features in any part; and the same is true of the Tuscaloosa formation. While, therefore, we might expect to find undulations and other irregularities in the strata of the Cretaceous, such disturbances are not easily recognizable in the three lower subdivisions of this group by reason of the uniformity in the lithological composition above noted. In the uppermost or Ripley division, however, there is more variety and some of the strata are easily identified, so that irregularities and disturbances in the stratification do not so easily escape detection.

While our observations in the Cretaceous territory have not been so extended as in the Tertiary, we are yet able to

note a few instances of well marked irregularities in the Ripley formation.

(1) CANTON LANDING, ALABAMA RIVER.

In the river bluff at this locality we have the following section of the Ripley strata:

Section at Canton Landing, Alabama River.

1. Surface beds covering first terrace of the river....undetermined.
2. Light gray, calcareous sands, with an indurated ledge of nearly pure sandstone at base.....6 feet.
3. Bluish gray, sandy clays, passing downwards gradually into a more sandy bed containing numerous phosphatic casts and nodules (sandy bed 3 feet thick)..... 8 feet.
4. Bluish, argillaceous, calcareous beds, holding great numbers of *Exogyra costata*, *Gryphœa*, and casts.....3 feet.
5. Bluish, calcareous sands containing many fossils, chief among which a *Spondylus*, a *Nautilus*, and turreted shells, to water level.....3 feet.

In one place here a block about 50 yards long of the face of the bluff has been broken from the rest of the strata and has settled down some six to eight feet, bringing the base of bed No. 2 of the section down to the top of No. 4 of the undisturbed strata.

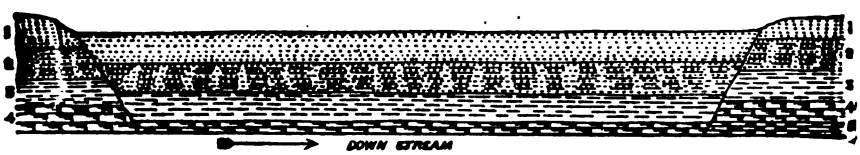


Fig. 1. Displacement at Canton Landing.

The figure gives an idea of this, and it is to be remarked further that the beds of the main bluff at the left of the break are lower than those at the right (with reference to the water level) by two or three feet.

(2) PRAIRIE BLUFF, ALABAMA RIVER.

At this place, as noted above, we have at the top of the bluff some 15 or 20 feet of fossiliferous, calcareous beds, in-

cluding part at least of those just given as occurring at Canton Landing, and below these to the river level some 60 feet of sandy strata traversed by bands of indurated sands containing numbers of large shells of Gryphæa and Exogyra. These sandy strata have a very rapid dip down stream (southward) of some 300 to 350 feet to the mile; while the calcareous beds at the top of the bluff, according to the recent observations of Mr. Langdon, show a much less decided dip, it being only about 30 or 40 feet to the mile. This may be, and probably is, due to the cross-bedding on a large scale of the sandy strata.

A mile or two above Prairie Bluff we have another exposure of the sandy strata, with similar rapid dip down stream. This dip, if uniformly continued down to Prairie Bluff, would bring these beds 300 to 400 feet below the visible portion of that bluff, while in all probability the strata of the two bluffs are, in part at least, the same, and it is probable that between the two places these strata undulate very decidedly or are perhaps faulted.

(3) MOSCOW, TOMBIGBEE RIVER.

Some of the calcareous beds of the Ripley formation are exposed along the right bank of the river from Moscow a mile or two down stream. In these bluffs, which are continuous, about fifty feet in all of these strata may be seen, and there is no difficulty in following any particular stratum to its disappearance below the water level. The strata here exposed are the following:

Section near Moscow, Tombigbee River.

1. Black, shaly clay like that of Black Bluff, supposed to be Tertiary, but devoid of fossils.....10 to 15 feet.
2. Dark blue, argillaceous limestone, with thin, projecting ledges of hard material. One of these ledges, about 8 feet below the black clay, is very persistent, and easily followed from Moscow down to the cut-off just above the mouth of Sucarnochee Creek.....20 to 30 feet.
3. Thin ledge of shells of a small *Gryphæa*.....1 to 1½ feet.

UP

(Black, shaly cla ts of cross-bedded sandstone embedded in the lime

2. Thin ledge of G ral faults are shown in this part of the river bank.)

DOWN.

he section on page 79.

DIAHE HOUSE) DOWN THE RIVER.

4. Hard, argillaceous, white limestone, resembling the Rotten Limestone, containing many Cretaceous shells, as *Exogyra costata Gryphæa vesicularis*, &c., especially in the upper part, which is indurated.....25 feet.

Near the top of stratum No. 4 there are at several places along the river hard, sandy ledges of very irregular shape, and discontinuous. These sandstones contain comminuted shells embedded in a sandy matrix. The thin ledge of gryphæa shells (No. 3) and an indurated ledge near the top of No. 2 are easily recognized, and they serve to identify the other beds.

In going from Moscow down to the cut-off we see that the above described strata are not only undulating but at seven or eight places distinctly faulted.

The accompanying diagram of the right bank of the river, carefully sketched from nature, shows very clearly the character of these disturbances and renders any further description in words superfluous (Plate XVIII).

Summary of the Leading Features of the Cretaceous Strata of Alabama. (Plate XXVIII.)

The whole thickness of Cretaceous rocks in the Western part of Alabama, according to our measurements and estimates, is between 2,550 and 2,575 feet, and the group has been divided into four formations, which are (1) the Ripley, (2) the Rotten Limestone, (3) the Eutaw, (4) the Tuscaloosa.

1. *The Ripley Formation.*—We cannot give the absolute thickness of this formation, but it will in all probability fall between 250 and 275 feet. The strata are; first, 55 to 60 feet of yellow sands,* in some localities containing many Cretaceous shells, followed by 100 feet of dark gray, nearly black, micaceous, sandy clays or clayey sands, traversed by hard ledges of similar materials, and along the two rivers at

*We have recently fonud conclusive evidence that the yellow sands are merely a modification produced by oxidation of the gray sandy clays next below.—E. A. S.

least, not prolific of fossil remains. Then 30 to 35 feet of bluish, argillaceous limestones, with great numbers of Cretaceous fossils, which are, however, mostly in the form of casts and generally phosphatic. Below this, again, a mass of sands (60 feet or more) of various colors, with indurated bands of sandstone running through it.

Topographical Features of the Ripley.—The eastern and western halves of the territory of the Ripley differ very markedly in their topography. In the former, the strata are prevalently somewhat incoherent micaceous, sands and heavy bedded joint clays, and the resulting surface forms are gently undulating, with here and there a ridge marking the presence of a more indurated ledge among the other beds. In the western part of the state, the indurated ledges of hard crystalline limestone and of calcareous sandy material alternate with the softer beds in such a way as to give a very broken and hilly character to the tophography, in very sharp contrast to the level monotonous plains of the prairie region immediately to the north. Other features of the Ripley are given above in connection with the discussion of the Cretaceous soils.

2. *The Rotten Limestone.*—In this we have the most massive of the calcareous formations of Alabama, outside of the Paleozoic. The thickness is about 1,000 feet, and there is surprising uniformity in the material, which is an impure, argillaceous and chalky limestone, merging in places into a calcareous clay. Where the clay predominates, we usually find the greatest abundance and variety of fossils. The strata of the Rotten Limestone form the bluffs along great stretches of both rivers.

Topographical Features of the Chalk or Rotten Limestone.—The uniformity in the composition of the Rotten Limestone has its influence on the topography of this region which is a low trough with gently undulating surface bounded north and south by hills which rise two or three hundred feet above the general level. The monotony of the plain is relieved by the occurrence here and there of ridges and con-

ical hills capped with the pebbles and sand beds of the Lafayette which at one time overspread the entire region. The irregularities of surface produced by the weathering of the Rotten Limestone itself are comparatively insignificant. In much of this territory the rocks lie near the surface and large trees are entirely absent; but on the other hand, there are many fine groves of oaks, walnut and poplar.

In all this region the surface water is strongly impregnated with lime and is often also insufficient in quantity. For a supply of this necessity recourse is had to artesian wells and cisterns, and for farm purposes, to shallow ponds. Cisterns are usually dug into the limestone rock and no brick work is necessary. Wherever the Lafayette materials lie over the Cretaceous rocks upon ridges, an adequate supply of pure freestone water is always to be had, and these sandy ridges are usually chosen as the sites for dwelling houses, and often for towns and villages. From the uniformity in the level, the waters falling upon this region are very slowly drained away, and much of it soaks into the ground converting it into mud, which when worked up by wheels of vehicles soon renders the roads nearly impassable.

3. *The Eutaw Formation.*—This formation has a thickness of not less than 300 feet. At the base of the Rotten Limestone we find some 20 to 25 feet of calcareous sands and greensands, in part strongly phosphatic, containing a large number of fossils, many of which are in the form of phosphatized casts. This bed forms a transition between this and the next succeeding formation. We place it with the Eutaw formation for the sake of convenience, with the remark that an examination of the fossils may hereafter show that it is more closely related to the Rotten Limestone.

Below these phosphatic sands are yellowish, cross bedded sands, 40 to 50 feet, and laminated, blue clays alternating with glauconitic sands for 40 feet more. The rest of the strata, to the base of this division, consist of laminated and cross bedded sands and laminated clays in many alternations, interbedded at intervals with lignitic strata consisting

of lignitized twigs and trunks of trees, not, so far as yet known, of beds of lignite. With these are one or two thin beds of pebbles. As before stated, the exact thickness cannot be given.

Topographical Characters of the Eutaw.—The nature of the strata as above indicated gives us a key to the topographic forms of the Eutaw.

The strata are very generally soft and somewhat incoherent and easily washed, hence the prevalence in this territory of deep washes and sharp steep hills. Some of the most broken country of the central part of the state is based upon this disposition of the prevalent strata.

4. *The Tuscaloosa Formation.*—The lower strata of the Cretaceous consist of a great thickness of clays and sands. These appear at intervals along the banks of the Tuscaloosa or Warrior River from Big Log Shoals up to the city of Tuscaloosa. Assuming a uniform dip of 40 feet to the mile the thickness will be about 1,000 feet. Along this river and toward the northwestern corner of the state there is apparently the greatest volume of these deposits which occupy very much less width of outcrop towards the east. We have not yet been able to ascertain the order of succession of the various strata which are mottled purple, and gray clays, yellowish and gray sands, pink and light purple sands and thinly laminated, dark gray clays holding many well preserved leaf impressions. In a general way we may say that the light pink colored sands are near the top of the series and the great masses of purple clays are nearer the base. From the leaf impressions the age of the Tuscaloosa deposits is fairly well ascertained to be approximately that of the Amboy clays of New Jersey.

Topographical Features of the Tuscaloosa.—The constituent strata of the Tuscaloosa loose sands, and heavy massive clays, give rise to sharp steep hills bordered with deep gullies, and where the clays prevail, these nearly vertical sides of the gullies have a tendency to slough off, sometimes in masses sufficient to cause small earthquakes. This ten-

dency is most frequently seen in railroad cuts and along the banks of the river. Instances might be quoted of sloughing cuts just above Cottondale on the A. G. S. Road, and below Snow's plantation on the Warrior several miles below Tuscaloosa. Along the dirt roads these clay beds form what are usually known as "Soap Hills." A noted instance is on the old stage road from Randolph to Centerville, long to be remembered by all travellers by stage coach in the *ante bellum* days. The roughness of the topographical forms within the borders of the Tuscaloosa is still further increased by the very common formation of crusts of iron oxide cementing the sands and pebbles of the Lafayette formation which is spread as a mantle over the greater part of the Tuscaloosa terrane.

RESUME.

EOCENE AND CRETACEOUS FORMATIONS, TOMBIGBEE AND ALABAMA RIVERS.

The general section forming Plate XXVIII is so arranged as to exhibit in the two inner columns, by conventions and descriptive text, the structure and character of the formations exposed along the Tombigbee and Alabama Rivers, and our conceptions of their relations. The portions of the sections in which the conventions are introduced are constructed from observations recorded in the foregoing pages and the portions left blank represent those parts of our ideal section in which exposures do not occur along either river. In the two outer columns are exhibited in similar manner those portions of the formations not actually seen along either river, which are either exposed in the immediate vicinity of the rivers so clearly as to leave no doubt as to their stratigraphic relations or else disclosed by artesian borings. These two columns, therefore, serve either to fill out the missing parts of the river sections or to confirm the measurements made elsewhere.

By reference to the text and to the general section it will

be seen that in the Eocene Tertiary group we have been able to fill up the blanks thus occurring along the rivers by direct measurement of the exposures seen in the vicinity of the rivers, except in two places, viz, just below the Bell's Landing section and below the Coal Bluff section of the Lignite. The stratigraphic column of this portion of the Tertiary formation, therefore, with the two exceptions noted, is constructed from actual measurements. From the known thickness of the several divisions which we have made in the Tertiary and their extent upon the surface, we find, from careful observations made at many points, that the average general dip of the Eocene strata is about 30 feet to the mile towards the southwest. There are, however, undulations and variations in the dip, culminating in the vicinity of the Tombigbee River, where the disturbances are more conspicuous than anywhere else in the post Appalachian clastics of the Atlantic and Gulf slopes, so far as known. These have been described in the preceding pages.

Similarly in the upper part of the Cretaceous group the stratigraphic column has been constructed in great part from actual measurements; but in the lower part, and especially in the Tuscaloosa formation, where our observations have been less numerous and satisfactory, we have assumed a uniform southwesterly dip of 40 feet to the mile, and the thickness thus assigned to the imperfectly exposed beds are only approximations, though, as we think, close approximations. In the artesian boring at Livingston, which is upon the extreme southern border of the Rotten Limestone, the thickness of this rock actually penetrated is 930 feet, and as the Rotten Limestone forms the surface between Livingston and Eutaw, a distance across the strike of 24 miles, the average dip is seen to be about 40 feet to the mile.

Some of the leading structural features of the formations described may be recapitulated.

The newest of the Eocene formations exposed along our route is the White Limestone. It consists chiefly of regularly bedded, impure limestone, with intercalated layers of

marl, calcareous clay and sand, and some ledges of pure limestone. Its upper portion is perceptibly more calcareous than the lower and contains a notably greater proportion of deep sea fossils; but neither the lithologic nor the paleontologic features are sufficiently distinct to warrant division of the formation. Its position and its structure alike indicate that it was laid down in a deep and probably deepening sea.

The Claiborne formation is made up of tolerably uniformly bedded, calcareous, and generally glauconitic sands and clays, containing rather shallow-water, but not littoral, fossils mingled with deep sea organisms. There is no unconformity or clearly marked line of demarkation between the Jackson beds of the White Limestone and the upper calcareous beds of the Claiborne, the one grading imperceptibly into the other, both lithologically and paleontologically.

The Buhrstone deposits are sands and clays variously interstratified, generally lithified by silicious cement. Some of the clays are remarkably pure and fine grained, and some contain a large proportion of silicified foraminiferal shells. The fauna is meager, but of facies identical with that of the Claiborne.

The Lignitic formation comprises three well marked divisions defined by color, which is here an index of constitution. The upper one-fourth consists of irregularly bedded, dark, silicious, and lignitiferous clays and heterogeneous sands, approaching the basal portion of the Buhrstone formation in composition and structure, interstratified with discontinuous beds of lignite and continuous layers of clay and sand containing marine fossils. The medial three-fifths of the formation is made up of rather more regularly stratified clays and sands of light color, frequently cross bedded, containing occasional beds of lignite and of marine sands yielding littoral fossils, one of which (the *Gryphœa thirsæ* bed) is 50 to 60 feet in thickness. The basal deposits are

irregularly bedded, dark, or even black, calcareous, shaly or slaty clays, with few fossils or definite beds of lignite, though considerable quantities of carbonaceous matter are disseminated throughout its mass.

At the base of the Lignitic there is a rapid change in the character of both rocks and fossils, the lowermost 15 or 20 feet of the Tertiary formation being limestone, at first argillaceous, then quite pure, and even crystalline. This crystalline limestone rests upon the sands which make the summit of the Cretaceous group, but whether conformably or not we have as yet been unable to determine.

The materials of the Ripley formation are generally fine and uniformly bedded, particularly toward the summit, are predominantly arenaceous at top and bottom, though notably calcareous, particularly in the middle layers, and are often richly phosphatic. The formation is characterized by littoral or offshore, but not strictly pelagic, fossils.

The Rotten Limestone consists of uniformly bedded and tolerably homogeneous, argillaceous, or rarely pure limestones, chalk, and clay marls, with occasional intercalations of clay and sand, sometimes glauconitic. Its abundant fauna is pelagic rather than littoral.

The transition beds between this and the Eutaw formation —the Tombigbee sand of Hilgard—are predominantly arenaceous and glauconitic, and speak of shallower waters than those of the Rotten Limestone.

The Eutaw deposits, like those of the Ripley, are usually fine and uniformly bedded, though they are more arenaceous than those of the latter formation. They consist of alternations of sand and clay, the former often cross bedded and glauconitic, and the latter lignitiferous, together with occasional lignitized tree trunks and intercalated beds of lignitic matter or pebbles. The rare fossils have a littoral aspect.

No unconformity has been found between the Eutaw and Tuscaloosa formations, and the similarity in lithologic char-

acter and attitude of the two is so close that search for discordance is unpromising.

The Tuscaloosa formation consists of a great series of irregularly or obscurely bedded, quartzitic and micaceous sands, often cross stratified; heterogeneous clays, sometimes carbonaceous or lignitiferous; lenticular pebble beds (the pebbles very commonly of chert); and discontinuous lignitic layers. With the exception of the lignite and leaf impressions, it has yielded no fossils.

The coarse sands and laminated clays forming the base of the Tuscaloosa formation repose unconformably upon the eroded surface of the Carboniferous and other Paleozoic rocks.

SECTION II.

THE TERTIARY AND CRETACEOUS FORMATIONS EAST OF THE ALABAMA RIVER.

By Daniel W. Langdon, Jr., Ph. D.

INTRODUCTION.

A careful study of the Tertiary and Cretaceous rocks exposed along the Alabama, Bigbee and Tuscaloosa rivers has given to the Survey data, from which to construct the General Section of these formations. While this section is unquestionably accurate for the area for which it was made and in which the observations were taken, the writer finds it to differ materially from the succession of rocks exposed along the banks of the Chattahoochee River between Columbus, Georgia and Apalachicola, Florida, as may be seen by the following table:

Formations.

			General* Section	hattahoochee section.
			Feet.	*Feet.*
Miocene	Alum Bluff		(Not seen)	65
	Chattahoochee		(Not seen)	250
Eocene	*Upper* (White Limest'e)	Salt Mountain	150	(Not seen)
		Vicksburg	140	250
		Jackson	60	25–30
	Middle	Claiborne	140–145	70–75
		Buhrstone	300	170–175
	Lower (Lignitic.)	Hatchetigbee	175	10
		Bashi	80–85	44
		Tuscahoma	140	173
		Nanafalia	200	175
		Naheola	130–150	(Wanting)
		Black Bluff, (Sucarnochee)	100	
		Midway, (Clayton)	25	218
Cretaceous	Ripley		250–275	1031
	Rotten Limestone		1000	(Wanting)
	Eutaw		300	345
Cretaceous (?)—Tuscaloosa (or Potomac)			1000 (?)	65

Series.

	General Section.	Chattahoochee Section.
	Feet.	*Feet.*
Miocene	(Not seen)	315
Eocene	1,655=	1,145=
Cretaceous	2,560=	1,441=
Total	4,215=	4,215=

* This is the classification used by us in Bulletin No. 43, U. S. Geological Survey. It has since been materially modified in certain parts; see above under "Present Classification."—E. A. S.

The greatest observed difference in the geological features of eastern and western Alabama, so far as the formations now under discussion are concerned, is found in the Cretaceous.

The Tuscaloosa group of the Chattahoochee River is composed mainly of sand and pebble beds; no such accumulations are seen as occur on the Tuscaloosa River and in Bibb and Chilton counties. Conspicuously absent are the leaf bearing clays, such as mark the lowest phase of the series further westward. In thickness it has become reduced from a thousand feet to less than one hundred.*

The Eutaw remains approximately constant in thickness, but in faunal features a decided change takes place. From the Tombigbee River eastward to the vicinity of Prattville, Alabama, no marine life has been noted, except in the uppermost part of the measures—though it is a question if these upper beds are Eutaw or a lower member of the Rotten Limestone; their position is the same stratigraphically as that of the somewhat equivocal Tombigbee Sands Group of Hilgard. From Prattville eastward, molluscan remains increase in quantity and in vertical distribution, being found, though lessening in number as well as in specific variety, from the base of the measures to the top.

The Rotten Limestone disappears entirely on the Chattahoochee, as far as anything lithologically resembling that rock is concerned. Whether or not this group does exist in this eastern drainage, is a question that can be settled definitely only by a careful study of the faunal features of the entire group—a very inviting, because, as yet, unexplored field. It is possible that the Rotten Limestone does exist on the Chattahoochee, but if so, there has been a marked change in the physical character of its sediments.

*This is true as regards the exposures along the river banks, but in the hills west of Girard, Tuscaloosa strata are exposed in a thickness of more than 200 feet. E. A. S.

On the other hand, the Ripley group, from the least important member of the Cretaceous formation in western Alabama, has become the most extensive. Because of the apparent absence of the Rotten Limestone, it seems to rest directly upon the Eutaw, causing an unconformity. In thickness it has increased from two hundred and fifty to a thousand feet, and in its surface extent bears the relation to the Cretaceous area of this section of the state that the Rotten Limestone does in West Alabama.

The Eutaw sands alone remain approximately constant, but exert no material influence over the soil or topography. The Tuscaloosa group is composed mainly of sands and pebble beds. No such accumulations of clay occur as are seen at Foster's Ferry and in Bibb and Chilton counties. No fossiliferous beds occur on this river such as exhibit themselves in the western part of the state.

To a great extent the Lafayette of Hilgard forms the surface of the counties of Conecuh, Covington, Dale, Geneva, Henry and Barbour, as well as southern Monroe, Mobile, Washington, Baldwin, Coffee and Escambia. The formation must not be confused with the Drift such as is found in the northern and western counties of the state, as it is, in the writer's opinion, younger and distinct. The differences will be cited in the proper place.

The fetid black clays and calcareous gray fossiliferous beds of the Port Hudson seem to have their eastern terminus in Mobile county on the western shore of Mobile Bay.* The ferruginous sandstone referred to by Toumey, is found on Mon Louis Island and is a member of this group.

The topography of that part of Alabama situated east of the Louisville and Nashville Railroad and south of the Montgomery & Eufaula Railroad is of such a nature that no high bluffs, so favorable to geologic investigation, and such as are afforded by the Alabama and Tombigbee drainages, occur, so that reliance has to be placed in the sections af-

*We have seen that the river equivalents of this Port Hudson—the Second Bottoms—are not thus limited in distribution.—E. A. S.

forded by Pea, Conecuh, Sepulgah, Choctawhatchee and Chattahoochee rivers, in which last, the strata, while not overlapping in disconnected bluffs, are consecutive, and for that reason more trustworthy. The individual topographies, particularly of the Buhrstone, Jackson and Wood's Bluff groups, so helpful in former work in tracing superficial occurrences, become valueless here under the obscuring influences of the Lafayette.

There is, too, a noticeable difference in the average dips assumed by the several groups of the two formations, being fifteen feet to the mile in the Tuscaloosa, forty-six in the Eutaw, twenty-seven in the Ripley and twenty-five in the Tertiary. These dips are calculated from exposures on the Chattahoochee River, and are believed to be accurate. The average, as will be seen, is nearly thirty feet, about the assumed dip for the Alabama and Tombigbee rivers. It must be understood, however, that there is no unconformity existing between the several groups of the Cretaceous, or between the two formations, the Cretaceous and the Tertiary, as all changes in inclination are gradual in passing from one stratum to another.

Wherever it was possible to identify Prof. Thornton's* localities I have referred to his report and settled more definitely the horizons of the strata. Many of these places were visited during the past season, but owing to the failure to specify more particularly the exact location of the outcrops, it was out of the question to identify all of them. It must be remembered, too, that since the publication of Prof. Thornton's notes, many of the small villages to which he refers, have become things of the past, and many of the county lines have been materially changed, as a comparison of the maps of that period and the present will show.

*Second Biennial Report on Geology of Alabama. M. Toumey, pp. 241-252. 1858.

GEOLOGICAL DETAILS.

TERTIARY FORMATIONS.

MIOCENE.

There is, some twenty-five miles below Chattahoochee or River Junction, Florida, the following section.*

(*a.*) *Alum Bluff, Fla.*

1. White sand, evidently marine, but of recent formation...30 feet.
2. Black lignitic sand, very pyritous, and from the efflorescence of ferrous sulphate, arises the name Alum Bluff. Variable in thickness and unfossiliferous.....10 to 15 feet.
3. Gray calcareous sand, highly fossiliferous, the principal shell being *Mactra similis*, Con. Varies in thickness with preceding stratum.....10 to 15 feet.
4. Gray sand, slightly calcareous, no fossils.....5 feet.
5. Light yellow sand, containing pockets of fossils. Where there are no shells the sand is very calcareous. To water's edge, and probably thicker than.....35 feet.

Owing to the high stage of the water it was not possible to collect many fossils from the lowest stratum, and only a partial series from the upper fossiliferous stratum is given.

Stratum No. 3 contains:

Ecphora quadricostata, Say.	Cardita granulata.
Buccinum porcinum, Say.	Pectunculus sobovatas, Con.
Conus adversarius, Con.	Arca incongrua, Say.
Cancellaria depressa, T. & H.	Arca lienosa, Say.
Typhis acuticostata, Con.	Mactra similis, Say.
Trochus philanthropus, Con.	Nucula (Leda) acuta, Con.
Fusus cinereus, Say.	Nucula dollabella, H. C. Lea.
Dentalium attenuatum, Say.	Nucula limitula, Say.
Oliva litterata, Say	Panopea reflexa? Say.
Ranella (Eupleura) caudata, Say.	Corbulata cuneata? Say.
Cadulus thallus. Con.	Cardita granulata.
Scalpellum, Nov. sp.	Solen ensis? Lin.
Crassatella Marylandica, Con.	Lucina cribraria, Say.
Venus concentrica, Gmelin.	Lucina sp.
Venus cancellata, Lin.	Tellina 2 sp?
Dione cribraria, Con.	Pecten eboreous, Con.
Mercenaria Rileyi, Con.	Ostrea disparalis, Con.
Circe metastriata, Con.	Chama congregata.

*Compare illustrated section, Plate XXIX.

Hipponix Bullii, T. & H.
Crepidula plana, Say.
Crepidula fornicata, Say.
Trochita centralis?
Crucibulum ramosum, Con.
Pyrula pyriformis, Con.
Drillia lunata Lea.
Natica heros. Say.
Natica duplicata, Say.
Turritella Purdenii? T. & H.
Voluta sp?
Charcarodon megalodon, Ag. tooth.
Balanus.

Stratum 5, from which only a few of the species collected contains among other fossils;*

Marginellalimatula Con.
Solarium perspectivum Lin.
Cytherea reposta Con.
Mercenaria tridachnoides Lam.
Cordita arata Con.
Cardium muricatum Lin.
Ceritium sp?
Orthaulax Gabbi Dall.
Hemicardium hemicardium Lin.
Lucina Pennsylvanica Lin.
Lucina divaricate Lam.
Tellina alternata,——

A comparison of the foregoing list with Meek's Check List† and the valuable compilation of Prof. Heilprin‡ shows that of the 63 species enumerated above, 44, or 70% are found in South Carolina; 40, or 64% are found in North Carolina; 26, or 41% in Virginia; and 24, or 38% among the newer beds in Maryland. A very fair inference then is, that these Alum Bluff deposits are members of Dana's Sumpter Epoch or Heilprin's Carolinian, only one of the species enumerated, *Crucibulum ramosum* Con., being found in Heilprin's Marylandian though a closer study of the fossils made possible by further collections, may point to a faunal relationship to an older epoch.

Immediately underlying these Miocene sands is a limestone of uncertain age, but which the writer is inclined to class with the Miocene beds.

Southward from Rock Island, nine miles by water, above Chattahoochee or River Junction, Florida, the white orbitoidal limestone disappears, and in lieu thereof, there is a rock more argillaceous and silicious in character, resembling some phases of Eocene Buhrstone. This limestone is

*These determinations were made by and with the assistance of Mr. Truman H. Aldrich of Blocton, Ala.

†Smithsonian Miscell. Col. vol. vii. 1867.

‡U. S. Tertiary Geology, Angelo Heilprin, 1884.

very well developed in a railroad cut about half a mile east of the Chattahoochee River; at Ocheesee, fifteen miles below the railroad bridge; and again at Rock Bluff, two miles below Ocheesee.

(*b*) *Section at Ocheesee, Fla.*

1. Argillaceous limestone, greenish yellow in color, no fossils seen, 10 feet.
2. A purer, more granular limestone, creamy white and soft, resembling the "chimney rock" phase of the Vicksburg group. Contains a few obscure corals to water's edge.....5 feet.

Rock Bluff, about thirty feet high is made up of strata of limestone varying in purity as at Ocheesee.

A consultation of the available literature of the Miocene, fails to give any idea of what division of that epoch is here represented, the authorities being apparently more interested in making long check-lists of fossils and describing new species, than recording the character of the strata from which the fossils were collected. Certain it is that this group overlies our Orbitoidal White Limestone and underlies the Miocene of the Alum Bluff and the writer inclines to the belief that it is properly referable to the Miocene, because of a certain impression of newness made on the observer. The only fossils found were a large *Pecten* about 3 x 3½ inches and an oyster resembling very closely, our living *Ostrea Virginica*, so that the question of exact age is one for some industrious paleontologist yet to settle.

For this older member of the Miocene or newest member of the Eocene White Limestone, the writer suggests the provisional name, "Chattahoochee Group," hoping that he is not guilty of the unpardonable fault of unnecessarily multiplying names. This group, estimated to be 250 feet in thickness, differs materially in its lithologic characteristics from any phase of the White Limestone yet observed in Alabama or Mississippi. On the rich black loam, derived from the disintegration of these slightly phosphatic limestones, the unique *Torreya taxifolia* or "Stinking Cedar" is found growing.

These outcrops at Chattahoochee, Ocheesee, Rock Bluff and Alum Bluff appear to be the western terminations of ridges that extend eastward parrallel to each other like gigantic ribs, and between these ridges are found some of the richest "hummock" lands in West Florida.

While these Miocene strata dip toward the south about twenty-five feet to the mile, and are soon covered by the sands and the cypress swamps so common along this coast, there are occasionally greater angles of inclination, as at Rock Bluff, where it is as high as 40 feet. The changes in the angles of inclination of these younger rocks would seem to indicate that the disturbance such as gave rise to the Hatchetigbee anticlinal* and the undulations of the Tertiary and Cretaceous strata exposed along the Chattahoochee, continued through Miocene times at least.

On subsequent canoe trips down Conecuh and Pea rivers, the writer failed to discover any Miocene deposits or any traces of the Chattahoochee Group.

EOCENE.

The White Limestone.

GEOLOGICAL NOTES.

Dr. Smith† has discussed the taxonomy of his group, with the main features of which the writer is in thorough accord. The uppermost or Salt Mountain division of this group is seen nowhere east of the typical locality and so does not enter into the geological features of this section of Alabama. As a matter of fact the character of the Salt Mountain limestone, composed as it is of corals, and spines of echini, and the occurrence of this isolated elevation, point rather to Salt Mountain's being an atoll or coral island built up in

*Bull No. 43, U. S. Geological Survey.

†Bulletin No. 43 U. S. Geol. Survey pp 19-35, 1887.

the Tertiary seas, rather than any extensive deposit, justifying the constitution of a group.

The Orbitoidal White Limestone, Hilgard's Vicksburg, continues eastward to the Chattahoochee River and into Decatur county, Ga. With the exception of a limited area in the western part of Covington county and the southern and eastern parts of Conecuh county this rock does not enter into the surface-making constituents at all, being obscured by the heavy covering of Lafayette. The last extensive outcrop of the Orbitoidal limestone seen in Monroe county is on Shoal Creek where it is exposed on either bank about three feet thick; this at Hatter's Mill near the line between Conecuh and Monroe.

The lower or argillaceous portion of this group seems to reach in Conecuh county, its highest development east of the Alabama River, making a final display of itself before disappearing east of the Sepulgah River. The "lime hills" of Smith are not found in this region, the deposit partaking more of the character of the typical outcrops between Jackson and Vicksburg, Mississippi.

Near Belleville, Conecuh county, the cream colored argillaceous limestone comes to the surface in little knobs seldom more than four feet above the general level, and is found in the swamp of Burnt Corn Creek, where it gives rise to numbers of cold, clear lime springs. In the plantation of Mrs. Ashley, Sec. 26, T. 5, R. 10 E., the gypseous clays come to the surface and give rise to regular black prairie soils. A well dug on this place gave the following:

(*a*) *Section in Sec. 26, T. 5, R. 10, Conecuh County.*

1. Lafayette, mainly red loam but toward the bottom composed of pebbles and white sand..... ....35 feet.
2. Hard gray ledge containing numerous bivalve casts, among which were *Pecten scintillatus* and *Pecten Poulsoni* ..... 2 feet.
3. Gray calcareous clay with an occasional stratum of *pyrite* but *no gypsum*. The pyrite was only partially decomposed and increased in quantity as the well was sunk deeper..... 35 feet.

A gully just north of the well exposes about 25 feet of the calcareous clays, which are here highly gypseous, crystals of that mineral weighing three pounds having been obtained from the locality. It would appear from this that the gypsum was the result of the recent double decomposition of the lime and pyrite, since it occurs only when stratum No. 3 has been subjected to atmospheric agencies. There is not enough gypsum to make this deposit of economic value.

This forms the southern limit of the prairies in this county, while the greater part of these lands, so valuable for agricultural purposes, lie north of this point. So that, if there be a recurrence of the lower division of this group of the White Limestone as at Choctaw Bluff* on the Alabama River, the Lafayette has covered it up. The Orbitoidal limestone forms the east bank of Murder Creek from this point to Castleberry Station on the L. & N. R. R. where it passes out of sight under the Lafayette.

East of the L. & N. R. R. no prairies occur, the few limy spots being the result of the disintegration of indurated masses of orbitoidal limestone which protrude above the surface of sandy loam. Such is the manner in which the Tertiary rocks assert themselves on the plantation of Dr. C. T. Taliafero, in Section 3, T. 4, R. 12. The softer "chimney rock" phase of limestone seems to have succumbed to eroding agencies, and when wanted for the purposes of making fireplaces, &c., has to be quarried ten or fifteen feet below the surface. The more persistent stratum of limestone, such as make up the "horsebone" or indurated outcrops, seems to be a constant quantity extending with only occasional interruptions, from a point just south of Belleville, Monroe county, to the Conecuh River.

Three miles northwest of Brooklyn, where the Brooklyn-Evergreen road crosses Bottle Creek, the calcareous clays of the lower division crop out on both banks of the stream. The percentage of lime in these clays has decreased visibly,

*Bulletin U. S. Geol. Survey, No. 43, 1887, p. 23.

and their influence on soil and vegetation, even when they come sufficiently near the surface to make the subsoil is practically *nil.* In fact their physical aspect is more akin to the Burhstone, having a semi-conchoidal fracture, and but for their stratigraphical position might easily be mistaken for the older group. These clays show a thickness of fifteen feet near the mouth of Bottle Creek.

At Brooklyn the Sepulgah River cuts some distance down through the Tertiary strata and on the east bank gives a very good section as follows:

(*b*) *Section at Brooklyn, Conecuh County.*

River Silt.....5 feet.
1. White calcareous sand, a mass of obscure casts, mainly bivalves .....6 feet.
2. Yellow calcareous sands forming on weathered surfaces root-like concretions ; unfossiliferous ..... 10 feet.
3. Calcareous gray clay the same as seen on Bottle Creek, to water's edge ..... 2 feet.

The "chimney rock" crops out only a short distance south of Brooklyn, the town quarry being two miles distant in that direction. Caves in this rock, resulting from aqueous agencies are quite common in the Orbitoidal limestone of this section; several have afforded places of retreat in times past to a number of legendary characters. Several of these caves contain bat guano of sufficient quantity to be of much value to the farmers in the immediate vicinity.

Some time ago this section of the state was much excited over the alleged discovery of coal in the bank of the Sepulgah River. An examination of the mineral found shows it to be species of fossil gum or resin, such as was seen by the writer in the White Limestone near the Mississippi line and in Clarke Co., and similar to that occurring in the Cretaceous limestone near Dayton, Marengo County. It was found in a small pocket in the calcareous clays, stratum No. 3 of the foregoing section.*

*See also above pp. 122, and 177.

As was stated before, this is the last occurrence eastward of the calcareous clays characterizing the lower, or Jackson of Hilgard, division of the White Limestone. This division now becomes more sandy and less calcareous even than before. In the N. W. ¼ of the N. W. ¼ of Section No. 35, T. 5, R. 14 E. a deep gully gives a section of Orbitoidal Limestone and the subjacent beds as follows:

(c) *Section of the N. W. 1-4 of the N. W. 1-4 Sec. 35, T. 5, R. 13 E., Covington County.*

1. Orange sand.....50 feet.
2. Cream colored Orbitoidal Limestone rather hard.....50 feet.
3. Gray sandstone slightly calcareous holding a few *Nummulina sp*, Ald..... 4 feet.
4. Pyritous glauconitic unfossiliferous sand..... .....6 inches.

Nos. 3 and 4, I place in the lower or Jackson division of this group.

The green sand No. 4 has been used by the farmers, but owing to the presence of the pyrite the effect was unfortunately deleterious tending to discourage them from any further experimenting in this line. Had the weathered portions of the orbitoidal limestone been applied to the land the results would have been more satisfactory.

On the banks of the small creeks flowing into the Conecuh River from T. 4, R. 14 the soft "chimney rock" is cut for use as chimneys in the neighboring farm houses. This is the last appearance of this phase of the White Limestone, all of it east of here being silicious.

About five miles southwest of Andalusia stratum No. 3 of the foregoing section comes to the surface without any warning. The country is a low and flat, long leaf pine forest, with an undergrowth of gall berries (*Ilex Glaber*) and containing here and there the pine flats with pitcher plants (*Sarraceniæ*) and their associate flora. For several square miles these glauconitic calcareous sands form the surface but have no effect upon the soil or vegetation, the branches and small creeks flowing through constricted banks, as if

rents had been made in the earth and the waters had accommodated themselves thereto.

The omnipresent Lafayette throws its obscuring mantle over the White Limestone from this point until reaching Pea River; the silicified masses of orbitoidal rock which occur in the northern part of Geneva and southern part of Coffee and Dale counties, owing their geographical position to secondary causes.

On Pea River, three miles by water below Dead River, and near the northwestern corner of Geneva county, a bluff shows the following section:

(*d*) *Section on Pea River.*

1. Yellow calcareous sands indurating at times into bowlders. The upper two feet is very fossiliferous, containing: Pecten nuperus, Scutella Lyelli, Ostrea sellæformis, Nummulite sp. Ald. and other genera undetermined ..... 15 feet.
2. Gray calcareous clay very much like that seen just below the Claiborne Ferruginous Sands at their typical locality. Lowest 6 very fossiliferous, containing: Scalpellum Eocense, Mr. Pecten nuperus, Pecten scintillatus, Ostrea sellæformis (var. divaricata)..... 4-10 feet.

Continuing down the river the following strata occurred:

3. Yellow sandy calcareous clay glauconitic, and containing *Scutella Lyelli*..... 65 feet.
4. Gray massive glauconitic calcareous sand..... 40 feet.
5. Gray sand and clay interlaminated and cross-bedded..... 2 feet.
6. Cream colored sands, slightly calcareous and apparently unfossiliferous, a weathered surface, however, showing sand casts of the following: Rostellaria velata (in quantity), Scutella Lyelli, Pectunculus Broderipii, Tworitella alveata, Crassatella protexta..... 8 feet.
7. Resembles physically the Alabama River Scutella Bed, but is somewhat less sandy and more argillaceous..... 2 feet.
8. Orbitoidal limestone, the lower part very soft and fossiliferous; species determined:—Orbitoides Mantelli, Pecten perplanus, Pecten nov. sp. ? Ostrea sp. ? large sellæformis? Thickness seen..... 25 feet.

It is rather difficult to determine exactly to which horizon stratum 6 of the foregoing section should be referred. Whether it be Claiborne or Jackson, can scarcely be ascer-

tained by its faunal features, as the fossils identified are common to both groups. Stratigraphy is of but little assistance in solving this question as groups disappear and thicken so unexpectedly, and change their character so materially in East Alabama that in some instances identifications by ordinary means are impracticable not to say impossible. From the fact that *Pecten nuperus* occurs below this stratum it is very probably Jackson.

From a point a few miles north of the Florida line the Tertiary is represented by a cream colored limestone devoid of lines of stratification, and seldom showing more than ten feet of thickness in either bank.

At the steamboat landing at Geneva there is an outcrop of a sandy limestone devoid of fossils but which is referable to this group of Tertiary formation; the succession of strata is as follows:

(e) Section at Geneva, Choctawhatchee River.

1. White sand and river silt.....10 feet.
2. Green sand, owing its color to very fine particles of glauconite; sparingly distributed, and containing an unrecognizable species of oyster in small fragments..... 3 feet.
3. White, slightly glauconitic calcareous sandstone unfossiliferous with the exception of some obscure casts.....10 feet.

The dip at this point, as indicated by the lowest stratum is about 30 feet to the mile southward. No. 3 may be seen under the bridge just north of the town where about ten feet show in either bank of the river. This limestone is seen on Pea River for the last time about a half mile south of the Florida line, where it disappears below the river alluvium.

Further east than this the writer knows of no outcrop of this group until reaching the Chattahoochee† where the

*At lower stage of the water, strata containing characteristic species of the Claiborne–e. g. *Ostrea Johnsoni*, *O. sellæformis*, have been observed below No. 3, which represents probably the base of the White Limestone or possibly the uppermost of the Claiborne.—E. A. S.

†See general account Part I. above, also County Details, Dale and Henry.—E. A. S.

banks are made up of it only a short distance in this state, the main body of the outcrop being in Florida. As seen here the White Limestone beginning about two miles below Gordon, Henry county, consists of two beds, the lower resembling more closely the Scutella Lyelli* bed of Smith, the upper, the characteristic white Orbitoidal rock. The writer is inclined to think that this Scutella bed, at least as it occurs in this part of Alabama, is more properly referable to the Jackson or lower division of this group than to the Claiborne group. About equal in number with the fossil that gives the stratum its name is that distinctly White Limestone species, *Pecten nuperus* and another Scutella (as yet undetermined). The lithological relation to Claiborne is not so strong perhaps as to render this paleontological evidence of no value. It is still the same calcareous ferruginous sand forming an indurated ledge wherever exposed to atmospheric agencies, and is here twenty-five feet thick extending geographically from just below Gordon to within about eight miles of the Florida line.

The white orbitoidal limestone immediately overlies the Scutella bed and maintains its general features, containing in its lower twenty feet numbers of echinoderms associated with its characteristic fossil.

And so has the White Limestone group been traced from the Mississippi to the Chattahoochee without interruption, forming a belt of varying width seldom exceeding twenty miles in either state and always exerting a beneficial influence over agriculture wherever natural agencies allow it to become a surface maker.

TOPOGRAPHY.

In that part of Alabama now under consideration the White Limestone seldom makes any topography by which it can be recognized as in the southwestern part of the state. In the main its influence is altogether negative, forming lime-sinks plainly seen until the Lafayette covering gets so

* Bulletin No. 43 U. S. Geological Survey p. 21, 1887.

thick that they cannot be recognized. Over a great area, lime springs, affording an abundance of cold, healthful water all the year round, flow from these rocks; the lakes in northwest Florida being due to the influence of this same group. Near Brooklyn in the N. E. ¼ of Sec. 13, T. 4, R. 13 E. are the only "lime hills" seen east of the Louisville & Nashville Railroad. The other territory underlaid by these rocks is monotonously level, there being barely enough inequality of surface to shed water.

USEFUL MATERIALS, SOILS AND VEGETATION.

Wherever the orbitoidal limestone has been exposed to frosts and sun sufficiently long, the soft, pulverulent marl arising from its disintegration, might be applied to the poor "piney woods" lands with much benefit, particularly when composted with pine straw, leaves or the cane stalks after the juice has been expressed in sugar making. The soils in this section, being generally deficient in lime, there need be no fear of putting on too much, the greater danger being in the opposite direction. The people of these counties already appreciate the value of the softer limestone for building chimneys and the harder phases for the underpinnings of their houses, the *modus operandi* of quarrying and dressing, i. e., with saw, ax and jack-plane being the same throughout its extent. As a soil maker this group is not of much importance. In Conecuh county and the western part of Covington it mingles with the red loam of the Lafayette (?) to make the red limy spots which produce grain crops so well, and on which, in uncultivated areas the cattle find such excellent grazing. In the neighborhood of Evergreen it gives rise to the black prairies and enters into the composition of the fertile creek bottoms between that point and Castleberry. East of the Conecuh River it is an unfelt and unknown quantity.

Fully ninety per cent. of the forest covering the area underlaid by these rocks, is, or was, long leaf pine, "Pinus australis" much of the finest timber having been ruthlessly de-

stroyed. Forest fires have not been so damaging as in other localities, owing to the fact not of their absence, but because there were no turpentine orchards to make martyrs of the trees. Much finely timbered land yet remains, and the railroads now projected through these counties will develop the milling industries to a considerable extent. In the creek bottoms several species of oak flourish, while on the sand ridges the turkey oak, (*Quercus Catesbœi*) makes its home.

A short, rather succulent grass, furnishes sufficient range for the rapidly increasing herds of cattle and flocks of sheep, which in winter subsist mainly on the reed growing in low, wet places, little stall feeding being required. As the weather is seldom, if ever, so severe as to necessitate housing or extra care, stock raising has proved remunerative to the small farmers of this section.

CLAIBORNE.

GEOLOGICAL DETAILS.

Closely associated throughout the extent of the White Limestone and next in order chronologically is the Claiborne Group with its several subdivisions* the Fossiliferous Sands, the Ostrea sellæformis bed, and the Lisbon strata.

With the first of these we have nothing to do in the territory now under discussion, no traces of it having been observed by the writer east of Monroe county.

The first Claiborne beds encountered after leaving those already noted by Dr. Smith, †occur on the east bank of Cane Creek, Conecuh county, on the land of Judge Tomlinson. This marl bed, for such is its character, crops out diagonally through Section 20, T. 6, R. 11, E. A high bluff on Cane Creek exposes the following:

* E. A. Smith, Bulletin No. 43, U. S. Geol. Survey pp. 25-27, 1887.
†Loc. cit. pp. 25-34.

(a.) *Section on Cane Creek, Conecuh Co. in N. E. ¼ of N. E. ¼, Sec. 20, T. 6, R. 11, E.*

Surface soil,..... 8 feet.
1.—Hard ledge of cream colored limestone containing numerous bivalve casts and a few *Ostrea sellæformis* Con..... 8 feet.
2.—Very coarse grained, white, unfossiliferous sand,.....45 feet.

On the same side of the creek, in the N. E. ¼ of the S. W. ¼ of Sec. 20, T. 6, R. 11, E. stratum No. 1, of the above section occurs as a light, yellow pulverulent marl, fifteen feet thick. This has been used with much benefit by Judge Tomlinson and others, and is in the proper mechanical condition for direct application to the land. An analysis of this marl, made in 1874, by Prof. W. C. Stubbs, then of the A. & M. College of Alabama, gave something over 25 % of lime as carbonate and only 54 % of inert matter, so that with the proximity of this bed to the fields now under cultivation, it should prove of great value to the neighboring farmers.

The next undoubted outcrop of this group occurs on Sepulgah River as follows:

(b.) *Section on Sepulgah Riv. in N. E. ¼ of N. E. ¼, Sec. 13, T. 4, R. 13, E.*

Red, limy surface soil,.....25 feet.
1.—Yellow glauconitic limestone, rather silicious full of bivalve casts and *Scutella Lyelli*, ...25 feet.
2.—Indurated ledge, light yellowish gray almost white, containing *Ostrea sellæformis*, ... 6 inc's.
3.—White, incoherent, calcareous sand with numbers of *Ostrea sellæformis* and *Scutella Lyelli*, ... 15 feet.
4.—Light, greenish gray marl, not apparently glauconitic, highly fossiliferous, the fauna being Lisbon or the lowest Claiborne, rather than the fossiliferous sands, through resembling the latter in lithological character, 12 feet.

A trip for a mile down the river, showed bed No. 3, to continue constant in its general features.

Thus we have the Scutella bed immediately above the Ostrea Sellæformis bed, the Fossiliferous Sands having thinned out entirely, it being the stratum of limited extent geographically instead of *Ostrea sellæformis* as supposed by Win-

chell.* Stratum No. 4, resembles physically the bed of comminuted oyster shells seen at Claiborne † and at Coffeeville, ‡ while in faunal features it seems to be a blending of the horizon just mentioned with the Lisbon bed No. 6, § of Dr. Smith's Section.

On Conecuh River and in the vicinity of Barrow's Mill Creek, the strata of the Claiborne group assume a decidedly lignitic phase consisting of dark brown, almost black clays, becoming more sandy in the upper portion, and containing numerous dicotelydenous leaves. A section exposed in the river bank between Barrow's Mill Creek, Sec. 15, T. 4, R. 15, and Prestwood's Bridge, Sec. 6, T. 3, R. 15 shows the following succession of strata.

(*c*) *Section on Conecuh River.*

1.—Yellowish gray sandy limestone containing numerous *nummulina*,..... 50 feet.
2.—Light colored sands and gray clays interlaminated and cross bedded, unfossiliferous,..... 25 feet.
3.—Lignitic sandy clay, less sandy at the bottom and full of leaf impressions,..... 8 feet.
4.—*Ostrea Johnsoni* beds..... 8 feet.

In the summer of 1885 Mr. L. C. Johnson of the U. S. Geological Survey, found in Sec. 15, T. 4, R. 15 E., a stratum, the chief fossil of which was an *Ostrea*, subsequently named in his honor by Mr. T. H. Aldrich.¶ This same deposit I found at the mouth of Barrow's Mill Creek, S. E. ¼ of S. E. ¼ Sec. 15, T. 4, R. 15 E., where there is the following section:

(*d*) *Section on Conecuh River, S. E. ¼ of S. E. ¼, Sec. 15, T. 4, R. 15, E.*

River sand, white.....2-5 foot.
1. Bed of shells in yellow sand. The shells are in the main very friable, decreasing in number in the lower part of the stratum,

*Proc. Am. Ass. Adv. Sci. Vol. X, Part II, p. 86, 1856.
†Dr. Smith's No. 11, Plate XIII, Fig 3, p. 147, Bull U. S. Geol. Sur. No. 43, 1887.
‡Loc. Cit. No. 5, Plate XIII, Fig. 4, p. 147.
§Bull, No. 43, U. S. Geolog. Survey, p. 30, 1887.
¶Bulletin No. 1, Alabama Geol. Survey, 1887.

the upper two feet of the stratum being as fossiliferous as the youngest of the Claiborne series. Most common fossils *Ostrea Johnsoni* and *Ostrea divaricata*, Con. var.....8 feet.

2. Blue glauconitic sands with very friable fossils among them, *Cytherea Nuttalliopsis*, Heilp.; *Venericardia planicosta*, Blain. and *Leda* (*protextissima*! Ald.) lithologically like the lowest Lisbon stratum*.....6 feet.

Immediately underlying the section last given is a succession of strata of argillaceous sands, varying only in the relative amount of clay, and in all cases glauconitic. These sands follow next above the Buhrstone, but, being unfossiliferous, it is a question whether to refer them to the Claiborne or the next lower group. As they are of limited geographical extent and exert no surface influences, they are not now of much importance.

The sands above mentioned crop out on the Choctawhatchie River under the County Bridge near Newton and make up the river bed for a mile down the stream, about thirty feet in all being exposed. At the next bridge, about two miles south of the "fish traps" opposite Newton, is the following:

(*e*) *Section 2½ miles South of Newton on Choctawhatchie River.*

1. Gray glauconitic laminated clay.....15 feet.
2. Green sand with a small quantity of clay but no fossils....3 feet.
3. Sandy silicious limestone containing large specimens of *Ostrea sellæformis*.....5 feet.

None of the Claiborne beds come to the surface, so far as the writer's information goes, between the Choctawhatchie and the Chattahoochee rivers, few of the streams cutting deep enough down to expose any Tertiary strata.

On the eastern border line of the state, the Claiborne beds begin at the mouth of Omussee Creek just below Columbia, Henry county. Here the island (on which Mrs. Caroline Lee Hentz left one of her heroines to die of exposure and

*Stratum No. 8 of Smith, Bulletin No. 43, U. S. Geol, Survey, p. 30, 1887.

starvation) around which the two branches of the creek flows, gives the following:

(*f*) *Section, Mouth of Omuskee Creek, Henry County.*

1. White sandy limestone containing small *Ostrea sellæformis* in abundance and pockets of larger sized shells of the same species.....6 feet.
2. Greenish yellow calcareous clay with an occasional large *Ostrea sellæformis*.....12 feet

The uppermost stratum of this section makes up the small bluffs between the mouth of Omussee Creek and two miles below Gordon, Henry county, the total thickness being only sixty feet, although the distance across the strike is about fifteen miles. The deposit is made up as before described of a white sandy limestone, containing numbers of small *Ostrea* and a few larger sized specimens of the same species. Alternate beds of soft and indurated strata mark decidedly the dips, for the return or northward inclinations are as steep and frequent as those toward the south. At Gordon there is a north dip of at least two degrees. These slight flexures account for the abnormal geographical continuity of this stratum, the sole representative in East Alabama of a group so diversified in lithologic and faunal characters in the Tombigbee and Alabama drainages.

TOPOGRAPHY, ETC.

The only influence noted as exerted upon the surface features by the members of this group, occur near Stallsworth's Mill, just east of Evergreen, Conecuh county. Here the ordinary flat pine woods are changed into rather sharply defined hills some twenty or thirty feet above the average water level of the surrounding country, and the vegetation is changed from long leaf pine (*Pinus Australis*) with its characteristic undergrowth, to Spanish oak (*Quercus falcata*) post oak, (*Q. obtusiloba*) and tulip or poplar trees, (*Liriodendron tulipifera*) indicating a stronger soil. Never a soil

maker directly, as is the case with more sandy or clayey deposits, acting only by combination with other superincumbent materials, such as the Lafayette or the red loam, its opportunities for influencing vegetation in this part of Alabama at least, are so limited that they may be reckoned as naught.

BUHRSTONE.

GEOLOGICAL DETAILS, ETC.

It is with much hesitancy and more reluctance that a separate group is made for the Buhrstone.* Tuomey says:† "I have shown in the report referred to (Final Report on the Geology of South Carolina) that the fossils of the South Carolina Buhrstone are identical, for the most part, with those of the Claiborne, and also agree with lower beds of the Virginia Eocene of the Pamunky," and then makes a separate group of our Buhrstone after recognizing it as the same rock of that name occurring in South Carolina. Hilgard,‡ on the other hand, seems to consider the relation between the organic remains of the Claiborne (as applied to those beds occurring at a bluff of that name on the Alabama River) and the Buhrstone (of Tuomey) so close as to make the divisions merely sub-groups.

An outcrop of Buhrstone on the south side of Hatchetigbee Anticlinal§ four miles from Bladen, gives the following species:

Ostrea divaricata, Con.	Pecten Lyelli, Lea.
Pyrula cancellata, Lea.	Discoflustrelaria Bouei, G. & H.
Rostellaria Whitfieldii, Heilpr.	? Cytherea Nuttalliopsis, Heilpr.
Rostellaria velata, Con.	? Dentalliun micro-stria, Heilpr.

Mr. T. H. Aldrich, to whom the paleontological work of the State Survey has been assigned, gives the following list from the Buhrstone rocks:

*In the present Report, and on the Geological map, the Claiborne and the Buhrstone are placed together as constituting the Claiborne division.—E. A. S.

†First Biennial Report on Geol. of Alabama, 1850, p. 163.

‡Agriculture & Geology of Mississippi, p. 123, 1860.

§Bulletin No. 43, U. S. Geol. Survey, p. 121, 1887.

Mitra Bolaris, Con.*
?Dentalium arciformis, Con.*
Tuba antiquata, Con.
Natica sp.
Sigaretus bilix, Con.*
Turritella carinata, Lea *
Mesalia vetusta, Con.*
Cylichna galba, Con.*
Cylichna subradina, Mr *
Nassa cancellata Lea.*
?Cassis Taitii, Con.*
?Ringicula biplicata, Lea.
Pyrula cancellata, Lea.*
Odostomia, 2 sp.
Nautilus, sp.
Lucina subvexa, Con.
Lucina papyraceæ, Lea.*
Venericardia planicosta, Blain.
Venericardia rotunda, Lea.*
Venericardia parva, Lea.
Limopsis ellipsis, Lea.
Corbula gibbosa, Lea *
Pecten Deshayesii, Lea,*
Nucula media, Lea.*
Cytheria trigoniata, Lea.*
Plicatula filamentosa, Con.*
Teredo sp.

All species marked with an asterisk were described originally from the Claiborne Sands.

Dr. Smith† says, speaking of the fossils found in this aluminous rock: "They do not appear to differ specifically from those of the overlying divisions," i. e. Claiborne. Unfortunately the organic remains of this sub-group are exceedingly rare and such as are found, are generally in the form of casts so indistinct as to be undeterminable. The richest field for the paleontologist seems to be in the southeastern edge of the Hatchetigbee anticlinal, where numbers of beautifully chalcedonized shells occur. The fauna of this sub-group has not been very closely studied in Mississippi, the following list being furnished by Hilgard‡ from a locality in Neshoba county.

Venericardia planicosta. Blain.
Voluta petrosa, Con.
Venericardi rotunda, Con.
Corbula gibbosa, Lea?

By comparing these forms with those found in typical Claiborne beds, the very close relationship, as evidenced by the organic remains, existing between the beds making up the strata next below the White Limestone and those next above the Lignitic will be plainly established.

So far as lithological character and peculiarity is concerned, aluminous rocks but slightly calcareous are found

* Bulletin No. 43, U. S. Geol. Survey, p. 121, 1887.
†Bull. No. 1. State Geol. Survey of Alabama, p. 10, 1886.
‡Agricult. Geolog. Report on Mississippi, p. 125, 1860.

in the intervening space between the fossiliferous sand and the Ostrea sellæformis at the typical locality, Claiborne.

At Horse Shoe Bend, on the Conecuh River, in the S. W. ¼ of Section 35, T. 5, R. 15, E., a stratum in the Buhrstone shows numbers of *Osteodes caulifera* Gabb, *and Osteodes Wailesii*, Con., the latter being a fossil of common occurrence in the *Ostrea sellæformis* beds of Smith's Claiborne Group.

Just below the mouth of Yantayabba Creek, Henry county, there is at the base of these aluminous rocks, a stratum twelve feet thick containing as many shells proportionate to the mass as will be found at any typical locality of the *Ostrea Sellæformis* sub-division, and in the same matrix. It might be urged that this may be the *Ostrea sellæformis* bed itself, and that the Buhrstone as it is known in East Alabama, has disappeared, as do so many of the Sub-Claibonrian strata. In reply to this the writer would say, that the superposition of the typical claystones to the extent of about one hundred feet, precludes all probability of mistake in this case. Sandwiched in between the two phases of what would be recognized as Buhrstone anywhere, is a bed forty-five feet thick containing *Ostrea sellæformis* Con (*vera divaricata* Lea) in great quantity.

The most eastern outcrop of this group* mentioned by Smith† is near the southwestern corner of Butler county, and this on the northeast or lowermost exposure of the division.

McClanny's Mill in Sec. 10, T. 8, R. 10, E., is built on an outcrop of this rock, about ten feet showing in the bank of Murder Creek. The southernmost outcrop seen in this section is about five miles northeast of Monroeville. From this point the strike seems to be about southeast, as the next outcrop believed to be near the top of the sub-division, is in Sec. 28, T. 6, R. 14, E., the rocks crossing the Louisville & Nashville Railroad between Mudge's Mill and Garland. The surface extent there is about ten miles north and south, the northern limit being marked by Persimmon Creek, the

*For the sake of convenience and to avoid confusion, the writer will use Dr. Smith's nomenclature.

†Bulletin No. 43, U. S. Geolog. Survey, p. 181, 1887.

southern bank showing, four miles from Georgiana, at a Mill, the following

(*a*) *Section on Persimmon Creek near Shell, Butler County.*

Surface soil.....8 to 10 feet.
1. Buhrstone Group.....120 feet.
2. Sands and sandy clays (Hatchetigbee) unfossiliferous.....30 feet.

The northern line of outcrop then passes through Section 27, T. 7, R. 15, E., where the following section is exposed in a hillside:

(*b*) *Section in Sec. 27, T. 7, R. 15, E.*

1. Orange sand, coarse white and pink sand.....6 feet.
2. Buhrstone, thin bedded, containing some fucoidal impressions, and inter-stratified with gray clays.....90 feet
3. Light colored sands and clays, Hatchetigbee.....50 feet

Traveling southward, the rocks of this division show in their outcrops along Conecuh River some characters, new and in a manner premonitory of what is to come further east. The sections below given will afford some idea of the occurrence and nature of these outcrops.

(*c*) *Section on Conecuh Riv. in S. E. 1-4 Sec. 20, T. 5, R. 16, E.*

1. Lafayette, containing a few quartz pebbles and in the lower portion half rounded bowlders of Buhrstone, 8 to 20 inches in diameter.....10 feet.
2. Buhrstone.....20 feet.
3. Light yellow sandy clay containing a great many obscure bivalve casts.....15 feet.
4. Unfossiliferous glauconitic gray sand, very slightly argillaceous and containing water-worn fragments of buhrstone.....7 feet.

(*d*) *Section at Horse Shoe Bend, Conecuh River in S. W. 1-4 of Sec. 35, T. 3, R. 15.*

White river sand.....5 feet.
1. Buhrstone passing into yellow clay, the whole filled with bivalves, some of them, especially *Cardium* sp? and *Veneri cardia planicosta*, attaining unusual size.....20 feet.
2. Fosiliferous glauconitic gray sand somewhat calcareous. The fossils are very friable, but among the most common are *Osteodes Wailesii* Con and *Osteodes caulifera* Con.....4 feet.

The occurrence of these two last named forms in this horizon is here noted for the first time.

At Bullock's Bridge, in S. E. ¼ of S. E. ¼ Sec. 3, T. 4, R. 15, the top of the Buhrstone rocks is seen dipping down the river rather rapidly, the angle of inclination being about 40 feet to the mile.

(*e*) *Section at Bullock's Bridge in S. E. 1-4 of S. E. 1-4 Sec. 3, T. 4, R. 15.*

1. Gray argillaceous glauconitic sands, unfossiliferous.....15 feet.
2. Buhrstone..... 5 feet.

Seven miles south of Elba, below Churchwell's bridge, in N. W. ¼ Sec. 13, T. 4, R. 19 E., this rock makes up the banks of Pea River for some distance. The southern extension of this outcrop is seen to present some characters rather peculiar to this particular locality. Pea River presents the following section given in its geographical, hence reversed stratigraphical order.

(*f*) *Buhrstone Section on Pea River.*

1. Buhrstone in ledges.....3 feet.
2. Yellow calcareous sand containing *Ostrea sellæformis* and a few obscure casts.....10 feet.
3. Buhrstone massive.....15 feet.
4. Marl resembling physically and in such forms as could be determined, faunally, Wood's Bluff, although most of the shells were comminuted.....1 to 3 feet.
5. Yellow glauconitic sand .....5 feet.
6. Buhrstone containing lignitic matter in lumps, sometimes as large as a hen's egg..... 12 feet.
7. Glauconitic sands, uufossiliferous.....(?)

Stratum No. 7 is a phase of the Buhrstone seen only in the drainages of Pea and Conecuh Rivers, appearing in its maximum observed development along the banks of the latter, and being noticeably thinner on Pea River.

Next we find Buhrstone outcropping a mile north of Ozark, Dale county, where it is quarried for building purposes. Here the aluminous character of the rock changes to a coarse argillaceous sandstone retaining the same color

as before, a very light buff. The upper strata of this group as seen in Sec. 35, T. 5, R. 23, are composed of glauconitic sandy laminated clays, unfossiliferous. Daleville is on the southern limit of the Buhrstone in this immediate vicinity. Buhrstone of a sandy type is found in Sec. 19, T. 4, R. 22, while Clay Bank Creek at Snell's Bridge, about five miles east, flows across the glauconitic clay phase of this group.

Near Abbeville, the Buhrstone takes the character of a coarse, quartzose conglomerate, this being at or near the base of the measures.

East of the Choctawhatchie River the writer was not able to find any outcrops of Buhrstone until nearing the Chattahoochee. Omussee Creek, a mile south of Columbia, Henry county, cuts through a calcareous phase of this rock, the perpendicular banks affording several fine mill sites. The smaller tributaries of this creek show, northwest of Columbia, outcrops of Buhrstone. On the Chattahoochee the last rocks of the next underlying group are seen just below the mouth of Yantayabba Creek, (familiarly known as Abbey Creek), and but for the stratigraphical relations the lowest rocks of this group would be mistaken for something of later age. For the better understanding of these rocks I shall give an extract from my Chattahoochee section, as exposed between Yantayabba and Omussee Creeks, and comprising all of the strata referable to this group. As will be seen the section is given in direct chronological order, beginning at the top.

(*g*) *Section of Buhrstone Rocks on the Chattahoochee River.*

1. White sandy limestone with small *Ostrea sellæformis* in abundance and pockets of larger shells of the same species. Forms capping ledge to the island at the mouth of Omussee Creek.....12 feet.

This is the base of the true or calcareous Claiborne.

2. Greenish yellow calcareous clay with a few decomposed fossils and an occasional large *Ostrea sellæformis*. This I take to be the top of the Buhrstone.....12 feet.

3. Cream colored silicious claystone slightly calcareous and containing alternate seams from about two to six inches thick of soft and hard rock, weathers into projecting ledges.....55 feet.

4. Light yellowish green sand containing numbers of small *Ostrea sellæformis*.....45 feet.
5. Cream colored aluminous rock, rather sandy in places...40 feet.
6. Coarse white sand containing *Ostrea sellæformis* (*var divaricata*) and a few other friable shells in upper part.....12 feet.
7. Gray lignitic sandy clay (Hatchetigbee) makes the top of the bluff at the mouth of the Yantayabba creek.....10 feet.

TOPOGRAPHY.

Probably the most marked topography in the counties of Choctaw, Clarke and Monroe, is that caused by the rocks of this group. Inequalities in the surface, amounting to what are locally termed "Mountains" rise three and four hundred feet abode the common drainage level in the section just named. After crossing the Louisville & Nashville Railroad this state of affairs ceases to exist, and with the exception of small areas near Oaky Streak, Butler county, and Churchwell's Bridge, Coffee county, where characteristic "mountains" occur, no surface influence is exerted by this group. In fact, with the exceptions named, there are no outcrops of the rock but what are made bare by the water courses, and until reaching the Choctawhatchie, the country is a stretch of level piney woods.

VEGETATION, SOIL AND USEFUL MATERIALS.

The vegetation most common to the group is long leaf pine, (*Pinus Australis*) and a few scrubby oaks, mainly "Black Jack," (*Quercus nigra*), but occasionally beds of shells come to the surface causing limy spots, and the growth of Spanish, post, white oaks and hickory indicate the stronger soil. In the territory now under consideration, this rock enters so little into the surface as to have no particular influence upon the vegetation or soil.

No tests have been made of the Buhrstone relative to its use as a fire brick. Some strata have been found that are practically infusible before the blowpipe, and the probabilities are that a refractory clay could be found that would serve for ordinary fire proof purposes, such as grate backs

and the interior of flues, if not for lining iron furnaces. The citizens living near outcrops of these rocks, use them for chimney making and for the underpinnings of their houses. In Ozark, the county seat of Dale, the rock has been extensively used for the purpose just named. The Buhrstone is easily quarried, and when some care in the selection of strata is taken, is worked with little trouble. Its use as a millstone is rather a doubtful probability; at least the writer has been unable to hear of its application to that purpose. The shell beds contain too much inert matter to be of any value for marling.

HATCHETIGBEE.

Next below the Buhrstone comes the first sub-division of the Lignitic group, which receives its name from the bluff on the Tombigbee River where it is well developed. The Hatchetigbee group is characterized throughout its extent by gray and cream colored sandy clays, at times calcareous, and nearly always interlaminated with sands, usually unfossiliferous. The first outcrop of these clays seen after leaving the territory already described by Dr. E. A. Smith,* occurs on Persimmon Creek, four miles south of Georgiana, viz:

(*a*) *Section on Persimmon Creek.*

1. Buhrstone ..... 120 feet.
2. Gray sands interlaminated with light colored sandy clays..... 30 feet.

But the best exhibition of this group in East Alabama is in the southern part of Butler county in what is known as Oakey Streak, an area about twelve miles long and eight miles in north and south extent, where all of the creek banks and washed hillsides show these gray sands and clays.

In Sec. 27, T. 7, R. 15 E., there is the following:

* Bulletin No. 43, U. S. Geological Survey, 1887.

(*b*) *Section in Sec 27, T. 7, R. 15 E.*

1. Coarse white and pink sand..... 6 feet.
2. Buhrstone.....90 feet.
3. Light colored sands and sandy clays.....50 feet.

Again in the gullies about Abbeville we have:

(*c*) *Section at Abbeville, Henry County.*

1. Lafayette.....35 feet.
2. Yellow micaceous sands, slightly argillaceous, probably the same as the following but weathered. No fossils seen.....8 feet.
3. Blue pyritous sand possessing all of the general features of the foregoing .....10 feet.

These sands I take to be Hatchetigbee.

On the Chattahoochee this group seems to have thinned out to almost nothing, the only representative being found at the mouth of Yantayabba creek as a bed of gray lignitic sandy clay, ten feet thick.

TOPOGRAPHY.

In Oakey Streak there are the rounded hills rising in little knobs above the surrounding country, such as are seen about Choctaw Corner, Clarke county, and other typical Hatchetigbee localities. East of Oakey Streak the Lafayette prevents any exhibition of peculiarities other than its own.

SOIL AND VEGETATION.

The disintegation of these laminated clays and their mingling with the sands occurring with them, give rise to a heavy clay soil that bakes very badly and suffers from extremes of drouth and rain. Where properly drained and cultivated good crops are produced, both of corn and of cotton, sufficient lime being present to adapt the soil to grain. The hillsides wash so much that they are usually abandoned after a few years cultivation.

Post oak seems to be the most commonly occurring of the forest trees the short leaf pine (*Pinus mitis*) being next in quantity, while red, Spanish and white oaks, together with sassafras, form the remainder of the sylva.

Wood's Bluff.

The sub-group bearing the name of Wood's Bluff is in West Alabama characterized by a marl bed occurring at the base of the Hatchetigbee clays and sands. In all of the counties west of the Sepulgah River this marl is well developed, and together with a hard gray sandstone, gives rise to a topography easily recognized. Such, however, is not the case in the eastern counties, neither topography nor marl making any appearance except along the watercourses, and then infrequently. Dr. Smith* mentions an outcrop of this marl on the headwaters of Sepulgah River. A careful search through the country east of this locality and inquiry among the people, failed to bring to light any outcrops of this marl except on the Pea and Chattahoochee Rivers. From the topography and the relative position of the Buhrstone, this series is believed to cross the L. & N. R. R. at or near Georgiana. In the vicinity of Elba, both east and west of Pea River, the rugged, broken country is such as usually characterizes the territory whose sub-stratum is formed by the rocks of this series.

In the NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ of Sec. 29, T. 5, R. 20 E., a gray sandstone, the same as is found above the Wood's Bluff marl at Choctaw Corner, and south of Lower Peach Tree, is quarried for millstones. An examination of the river near that point shows:

(*a*) *Section in S. 29, T. 5, R. 20 E.*

1. Wood's Bluff marl .....
2. Laminated, gray, sandy clays .....20 feet.

*Bulletin No. 43 U. S. Geolog. Survey, 1887.

No trace of the lignite, such as is found at all outcrops of these underlying clays on the Alabama and Tombigbee rivers, could be discovered in this vicinity, though special search was made.

From Elba southward down Pea River there is an abnormal development of the Wood's Bluff or Bashi Group. In lieu of one marl bed as seen in the vicinity of the typical locality there are three well marked strata containing fossils charcteristic.

(*b*) *Section on Pea River from Elba to 2 miles below Churchwell's Bridge.*

1. Super Bell's Landing clays, sandy and containing rounded bowlders; no lignite seen.....75 feet.
2. Yellow sands with Wood's Bluff fossils, and a bottom layer of large *Cardita planicosta* and *Ostrea compressirostra*.....20 feet.
3. Laminated gray clays.....25 feet.
4. Wood's Bluff fossils in a gray sand matrix. Fragments of a *Nautilus* found here.....4–6 feet.
5. Dark colored, sandy laminated clays.....15 feet.
6. Yellow sand with pockets of Wood's Bluff fossils. This stratum is somewhat argillaceous and presents a massive surface, 8 feet.
7. Dark gray, highly glauconitic stratum containing some Wood's Bluff forms.....2 feet.
8. Yellow sand with bowlders; no fossils seen.....10 feet.
9. Laminated gray clay (No. 8 and No. 9 are in all probability the local representatives of the Hatchetigbee group).....15 feet.
10. Buhrstone ledges.....5 feet.

Strata Nos. 3, 4, and 5, are found immediately under Churchwell's Bridge seven miles south of Elba. The sandstone used in the vicinity for millstones is an indurated phase of stratum No. 2 of the river section.

Near Skipperville, Dale county, and about Section 30, T. 7, R. 26 E., the west bank of the Choctawhathie River shows:

(*c*) *Section in Sec. 30, T. 7, R. 26 E.*

1. Laminated clays and cross-bedded sands with occasional masses of soft white rock containing numerous undetermined casts, 8 feet.
2. Highly glaconitic sand.....2 feet.

3. Lignitiferous sand of brownish hue, probably the weathered outcrop of a lignite.....6–9 inches.
4. Red, cross-bedded sands and gray laminated clays alternating, 15 feet.

On the surface was found a small gray sandstone bowlder, containining a few obscure casts and resembling in their physical characters those peculiar to the Woods Bluff series in West Alabama, so that I feel no hesitancy in referring this outcrop to that series. The presence of the basal lignite here is interesting.

This series is poorly represented on the Chattahoochee River and without the basal lignite to mark the boundary, it will not be easy to separate it from the Bell's Landing series beneath. The probabilities are that the series of laminated sands and sandy clays found occurring in this subdivision in the Alabama and Tombigbee drainages have thinned out so as to bring the two marl beds very close together. In the Horse Shoe Bend just below the mouth of Yantayabba Creek a bluff gives the following:

(*d*) *Section on Chattahoochee River, above the mouth of Yantayabba Creek.*

1. Light yellow sandy limestone filled with obscure casts and containing pockets of *Ostrea compressirostra* Say. unlike anything before seen in this horizon.....18 feet.
2. Blue sandy clay.....6 feet.
3. Gray sand composed of decomposed fossils (an irregular indurated ledge, unfossiliferous, occurs in this stratum...18 feet.

Unless the Wood's Bluff series enters into the make up of the Oakey Streak country, the writer knows of no section where it comes to the surface, so that as a maker of soils and as an influencing factor with vegetation it is unknown east of Monroe county. The only feature of economic value is the hard gray sandrock mentioned above as occurring near Elba. In this locality it has been used for mill rock, the price ($5.00 a pair for the stones undressed) yielding the owner of the land a very nice income. This stratum is however, too varied to be of any particular importance.

The Bell's Landing Series.

Concerning the rocks of this series very little can be said, for while they remain more persistent perhaps than any of the sub-groups of the lignitic division, they enter into neither the topography nor the soil, occurring as mere outcrops on the rivers. The first that we have going eastward is a limited occurrence on the Conecuh River, where the sandy clays of this group form low disconnected banks. The strata referable to this series are first seen about Section 25, T. 7, R. 18, and continue at intervals in the river bank until reaching Section 26, T. 6, R. 17, where a bluff about 25 feet high is made up of the sands and sandy clays peculiar to the group.

On Pea River however, the series is better represented. Rocky Mound P. O., Dale Co., two miles east of Munn's Mill is on the lower Peach Tree phase of these sandy clays, but on a high ridge, thus accounting for their occurrence so far northward. On the river proper, the first outcrop of this group is seen near Cole's Bridge, Section 8, T. 7, R. 22, where the typical marls containing *Ostrea compressirostra* occurs. From this point southward to three miles from Elba the Bell's Landing group constitutes the river bank. The bluffs seldom higher than 15 feet, are so disconnected and the stream so tortuous that no attempt was made to estimate the thickness on Pea River.

(*a.*) *Section at Elba, Coffee County.*

1. Red and yellow sandy clays, laminated and unfossiliferous..18 ft.
2. Greenish yellow sandy clays, same as preceding.....20 ft.
3. Rounded bowlders of sandstone, unfossiliferous..... 8 ft.

The following section also is believed to belong to this group:

(*b*) *Section on the Choctawhatchie River at the crossing of the Clayton & Abbeville Road, about 6 miles from Abbeville.*

1. Gray sandy clays, interstratified with red sands, unfossiliferous.....20 ft.
2. Gray sandy laminated clays, no fossils seen.....125 ft.

The section exposed along the banks of the Chattahoochee is about one hundred and seventy-five feet thick and is composed of light yellow and gray sands and sandy clays, containing in the sandier portions lines of rounded bowlders. The series is unfossiliferous throughout its extent with the exception of the uppermost three feet, and becomes more sandy toward the top. Geographically it stretches from about four miles below Ft. Gaines, Ga., to about a mile north of Yantayabba Creek, a distance across the strike of about ten miles. The fossiliferous stratum referred to corresponds to the Bell's Landing bed and contains quite a number of *Ostrea compressirostra* Say. and *Venericardia planicosta* Blainv. both very large; the other shells are too badly decomposed to be recognized.

The Nanafalia Series.

The *pseudo-buhrstone* phase of the Nanafalia group is the only representative of any consequence that this series possesses in the counties now under consideration. The undulations which have given rise to the Grampian Hills of Wilcox, as well as the more calcareous strata of the typical outcrop such as make the fertile lands of southern Marengo and Wilcox counties, have alike disappeared. Instead we have a gently rolling piney woods country with an undergrowth of oaks, and not possessed of any characteristic soil. The fossils too, seem to be of less frequent occurrence and only an occasional *Gryphœa thirsœ* Gabb. serves to thoroughly identify the rocks. This series has been followed from the Mississippi line to Butler Springs, Butler County, by Dr. Smith,* and it will now be my object to trace this formation on eastward to the Georgia line, thus determining its geographical extent in the state.

In the neighborhood of Forest Home and Monterey the heavy beds of red loam obscure all outcrops of Tertiary strata. Traveling toward Greenville from the latter place, the hard claystones of the Nanafalia series are encountered

*Bull. No. 43, U. S. Geolog. Survey 1887.

about eight miles west of Greenville. The northern line of outcrop extends to within a short distance of Manningham, then turns southward and crosses the railroad just above the line between townships nine and ten. The southern limit of these rocks is found in Sec. 22, T. 9, R. 12, E. and extends thence eastward to Garland. The magnificent pine forests whence comes the supply of the Flowers and other neighboring lumber companies, are sustained by the soil derived from the disintegration of these silicious claystones. After leaving the vicinity of Butler Springs I saw no evidence of the presence of lime in the outcrops of this rock as far east as it was followed.

On Conecuh river the rocks of this formation make but a small portion of the banks of that stream. The first exhibition of this series is some three miles south of Spier's Bridge, (Sec. 21, T. 8, R. 19, E.) where a small bluff shows:

(*a*) *Section on Conecuh River.*

1. Debris.....13 feet.
2. Hard ledge containing *Gryphæa thirsæ*..... .1 foot.
3. Gray sands, with a few indistinct fossils.....3 feet.

The other bluffs about a quarter of a mile apart, and two miles below the section just given, exhibit the pseudo-buhrstone phase of the Nanafalia group on the river. The highest of these two bluffs is some fifty feet above the water, the other only about fifteen feet. Neither possesses any special features.

In the N. W. $\frac{1}{4}$ Sec. 9, T. 8, R. 16, in rolling piney woods, the Nanafalia group again comes to the surface, and may be traced thence to about Sec. 27, T. 8, R. 19, E., thence to the N. W. $\frac{1}{4}$ of the N. E. $\frac{1}{4}$ Section 25, T. 9, R. 26, thence to N. E. $\frac{1}{4}$ of N. E. $\frac{1}{4}$ Sec. 17, T. 8, R. 22, E., thence where the following may be seen.

(*b*) *Section on Troy & Ozark Road in N. E. 1-4 of N. E. 1-4 Sec, 17, T. 8, R. 22.*

1. Purple sand merging gradually into a sandy clay (Lafayette) 20 feet.
2. Rather soft phase of *Pseudo-Buhrstone*, not very fossiliferous. The bottom of the series.....5 feet.
3. Sands, with thin laminæ of gray clay. The sand is light purple and unfossiliferous.....10 feet.
4. Massive green sandy clays weathering purple, and unfossiliferous. Seen on opposite hill.....15 feet.

In an old field in the N. W. ¼ of the N. E. ¼ Sec. 15, T. 8, R. 25, there are some bowlders of an unfossiliferous pseudo-buhrstone phase of this series.

From this point the outcrop crosses Pea River about two and a half miles north of the Dale county line, thence to Fort Gaines it is covered by the Lafayette, making its first appearance in the river bluff opposite Franklin, Alabama. So much for the northern limit of this sub-division.

After crossing the railroad at Bolling, the next outcrop examined by me was in the neighborhood of Bullock, Crenshaw county, although I was told of the occurrence of *Gryphœa thirsœ* Gabb. in Butler county, east of Bolling From this last named appearance of this rock on to the Chattahoochee, heavy beds of surface sands prevented the tracing of the southern outcrop of this series.

At Munn's Mill, on Pea River. in the northeast corner of Dale county, the foundations for the dam are cut into the marl of this series. From what I could see, I take this to be about the top of the group, hence the southern limit of the Nanafalia rocks in this part of the state.

(*c*) *Section at Munn's Mill, Dale County, Sec. 6, T. 7, R. 23.*

1. Gray sands, slightly argillaceous, massive and weathering, light yellow.....10 feet.
2. Pseudo-Buhrstone ledge no fossils seen.....1 foot.
3. Gray sands.....10 feet.
4. Gryphæa thirsæ bed seen.....4 feet.

Mr. Munn tells me that the shell bed, (4) becomes more glauconitic and less sandy in the lower part, and is in all about 10 feet thick. The river alluvium obscures these rocks on Pea River north of this point. The water power here is magnificent, the stream being about 300 feet wide, with a 12-foot fall, and is seldom interfered with by freshets and never by scarcity of water.

At Ft. Gaines, Ga., there is a high bluff exhibiting the following succession of strata.

(*d*) *Section at Ft. Ganies, Ga.*

1. Yellow cross-bedded sands, the bedding planes marked by gray clay ..... 10 feet.
2. Glauconitic coarse sand, filled with large *Ostrea Compressirostra* Say. *Venericardia planicosta*, Blain. and small specimens of *Pecten Deshayesii*, Lea. (Teeth of a sauroid were found also.) 2 feet.
3. Greenish gray, fine grained calcareous sand, very firm and holding decomposed shells, mainly bivalves ..... 6 feet.
4. Dark gray, argillaceous sands, with few fossils and fragments of water-worn clay. The lower part becomes more fossiliferous, containing *Osteodes caulifera Venericardia planicosta* Blain., and *Gryphæa thirsæ* Gabb ..... 6 feet.
5. White and lignitic cross bedded sand and sandy gray clay, containing one or two ledges of pseudo-buhrstone ..... 50 feet.
6. Gray calcareous sandy clay with bowlders of sandstone and a few decomposed *Gryphæa thirsæ*, Gabb ..... 15 feet.
7. Irregular bed of glauconitic sand filed with *Gryphæa thirsæ*, Gabb. *Venericardia planicosta*, Blain., and *Crassatella tumidula*, Whitf. This stratum rests upon the water-worn surface of the following: 8 to 12 feet.
8. Light yellow limestone filled with casts and a few large *Ostrea compressirostra*, Say. Large irregularly shaped pockets of white sand enclosed in black clay occur in "pot holes" throughout the stratum ..... 15 feet.

The section just given is the first of the Nanafalia series seen on the Chattahoochee. A marked peculiarity of this sub-group on this river is the number of *Ostrea compressirostra*, Say, found occurring throughout its thickness, equal in quantity to the *Gryphæa thirsæ*, the hitherto typical fossil. The succession of the strata of this series as seen between Ft. Gaines, Ga., and Wood's Shoals, is as follows:

(*e*) *Section of the Nanafalia on the Chattahoochee River.*

1. Yellow and gray sandy clays, containing occasional beds of *Ostrea compressirostra*, Say, and *Gryphœa thirsœ*, Gabb. The indurated ledges are of the nature of the *Pseudo-Buhrstone* or the "Grampian Hills Rock," and are filled with casts of bivalves, the only exception being *Turritella Mortoni*, Con., which is here very large ..... 75 feet.
2. Yellow cross-bedded sands, the bedding planes marked by gray clay ..... 10 feet.
3. Glauconitic coarse sand, filled with very large *Ostrea compressirostra*, Say., *Venericardia planicosta*, Blain., and small specimens of *Pecten Deshayesii*, Lea. Teeth of some sauroid animal were found in this stratum ..... 3 feet.
4. Greenish gray, fine grained calcareous sand, very firm, and holding decomposed shells, mainly bivalves ..... 3 feet.
5. Dark gray, argillaceous sands with few fossils and water-worn fragments of clay. The lower part becomes more fossilliferous, containing *Osteodes caulifera*, *Venericardia planicosta*, Blain., and *Gryphœa thirsœ*, Gabb ..... 6 feet.
6. White and lignitic cross-bedded sand and sandy gray clay, containing one or two ledges of *pseudo-buhrstone* ..... 50 feet.
7. Gray calcareous sandy clay, with bowlders of sandstone a few decomposed *Gryphœa thirsœ* ..... 15 feet.
7. Irregular beds of glauconitic sand filled with *Gryphœa thirsœ*, Gabb. *Venericardia planicosta*, Blain., and *Crassatella tumidula*, Whitf. 8 to 12 feet.

Prof. Thornton* mentions the occurrence of a sandstone and a silicious limestone, containing numbers of casts. These are both members of this series, the "Silicious Limestone" being a phase of the *pseudo-buhrstone.*

There is some little doubt in my mind whether or not the fertile red lands of east Butler and west Crenshaw counties are derived directly from the rocks of this series, or are the result of a commingling of loam with the weathered surface of this sub-division. In the neighborhood of Rutledge fragments of *Grgphœa thirsœ*, Gabb., particularly the under valve, are frequently found distributed at irregular intervals through the red loam, which makes the soil. Suffice it to say, that here again we have an example of the beneficial

*Second Bien. Rep. on Geol. of Ala., M. Tuomey, p. 244, 1858.

influence exerted by this series over the agricultural industries.

The softer strata of this rock are quarried for use in chimneys and hearthstones, notably in and about Brundidge, Pike county. Attempts have been made to burn lime from these rocks and the result is what might have been expected, a failure. In the neighborhood of Henderson's Store, Pike county, is the best development of this series seen east of the Louisville & Nashville Railroad.

Other Members of the Lignitic Group Below the Nanafalia Series and Above the Midway Series.

So far as concerns the persistency of the sub-Nanafalia series the writer feels himself somewhat at a loss to speak with that degree of accuracy which has accompanied similar work of the Survey in the western counties of the Tertiary region of Alabama. Disconnected, and, in some instances, overlapping sections are seen, but these are unfortunately too few to make the inland section complete for the area situated between the Sepulgah and Chattahoochee drainages. It is to be hoped that another summer's work will settle many points now in doubt, and so make our account of the Tertiary of Alabama as complete as possible.

In the preceding chapter I depart somewhat from the classification of Dr. Smith* in that I do not take up the strata subjacent to the Nanafalia series and including the Coal Bluff lignite, under the same heading with the series characterized by the extensive deposits of *Gryphæa thirsæ*, Gabb. The chief reason for not including the cross bedded sands and sandy clays of the Coal Bluff series with the Nanafalia beds, is not so much the difference in lithologic character, which is indeed strongly marked, as in the fact that all of that portion of the Tertiary between the Nanafalia series and the lowest number of the Midway series

*Bulletin No. 43, U. S. Geol. Survey, 1887.

thins out so much, going eastward, as to disappear entirely on the Chattahoochee River.

In the following chapter I shall consider the remaining part of the Lignitic Group not already treated of as one series, there being no reason in East Alabama to separate it into sub-groups.

The *Coal Bluff Sands* and *Lignite* are last seen on Pursly Creek just south of Camden, for while in the neighborhood of Oak Hill there is a vague rumor of the existence of lignite in the vicinity, no trace of it could be found. Prof. Thornton† gives the following section as occurring on the Conecuh River.

(*a*) *Section at Spier's Ferry on Conecuh River.*

1. Surface bed of coarse red sand.
2. Bluish-white clay with casts of shells. This layer contains small transparent needle-like crystals which have the taste of alum.
3. A bed of lignite 20 inches in thickness. A portion of the wood is converted into a dark compact substance, while the greater part retains its original structure. On the surface is a white efflorescence caused by the decomposition of iron pyrites which exists in the lignite in the shape of cubic crystals.
4. Purplish sand and clay.
5. Purplish sand and clay with decomposed shells.

The exact location of this outcrop I have been unable to determine, but am fully satisfied that it is the Coal Bluff or Landrum's Creek Lignite. It is much to be regretted that Prof. Thornton gave neither the thickness nor the exact location of the deposits.

A mile below Spier's Bridge the east bank of Conecuh River shows the following section, which I believe to be Prof. Thornton's section, although I am not altogether sure of the identity of the two.

(*b*) *Section on Conecuh River, Sec. 21, T. 8, R. 12, E.*

1. Purple and yellow sandy clays and micaceous sands interlaminated.....10 feet.

†Second Bienn. Report on Geol. of Ala., M. Tuomey, p. 246, 1858.

2. Lignite.....3 feet.
3. Purple sands and debris.....20 feet.
4. Brown lignitic sands containing lenticular masses of mica scales, sometimes held together by pink clay but more frequently resembling pieces of weathered mica schist.....2 feet.

The following section is seen in the next bluff occurring on Conecuh River, No. 1 of this section corresponding to No. 3 of the foregoing.

(c) *Section on Conecuh River, N. W. ¼ of N. W. ¼ of S. 28, T. 8, R. 19.*

1. White and pink coarse grained sand.....30 feet.
2. Coarse black sand containing thin irregular streaks of lignite about a sixteenth of an inch thick.....2 feet.
3. Brown argillaceous coarse grained sand.....4 feet.

Since the pseudo-buhrstone phase of the Nanafalia series is found on the neighboring hillsides within two miles of the river, I think this is unquestionably a member of the Coal Bluff series and possibly the lignite itself. When next seen this lignite crops out twice in the same vicinity, so that the section exposed would be:

(d) *Section in Sec. 25, T. 8, R. 23 E., Barbour County.*

1. Pseudo-buhrstone (Nanafalia).....10 feet.
2. Light yellow sand becoming red and slightly calcareous on descending.....30 feet.
3. Black lignitic clay (the outcrop of the lignite).....3 feet.
4. White sand.....2 feet.

Further east than this I know of no lignite. The hypsometric difference between the Nanafalia and the Midway group is here only eighty feet, while on the Tombigbee River it is two hundred and fifty.

The Matthews's Landing and Black Bluff Series.—The marl bed characterizing the Matthews's Landing series crops out on Wolf Creek, Butler county, in Sec. 34, T. 11, R. 13, where about ten feet of gray micaceous sands are seen containing *Venericardia planicosta*, Blain, and *Nucula magnifica*, Lea. The same marl may be seen in the

western outskirts of Greenville just west of the depot; further east than this the writer knows of no fossiliferous deposits referable to this series.

From Greenville on towards the Chattahoochee River the beds of surface sands hide nearly all of the lower Tertiary rocks, particularly these sands and clays, to such a degree that only the thickness of the individual outcrops can be determined, and that only at rare intervals. In and about Troy and Brundidge the red, calcareous lands are derived from these sands and clays mingled with disintegrated portions of the next succeeding series. Probably the best example to be seen in East Alabama of this part of the Tertiary is on the road from Hendersonville to Brundidge and from Brundidge to Troy.

The red sandy clays on the Brundidge-Troy road are underlaid by a stratum about four feet thick of coarse grained yellow sand, containing calcareous concretions, as if the fossil shells had become decomposed and the lime partially dissolved by the percolating waters, and afterwards segregated. This sandy stratum appears to be the source of the greater part of the water in the vicinity. A well in Brundidge gives the following section:

(*a*) *Section of Well in Brundidge.*

1. Red and yellow sandy clays.....88 feet.
2. Gray, calcareous clay.....12 feet.
3. Cream colored fossiliferous limestone.....

As the well has been dug for some time, I had to rely on a Mr. Watson, on whose place it was, for the above particulars, though fragments of the limestone and the weathered remains of the other strata were seen about the mouth of the well. Just south of Brundidge, on the Ozark road, there is a hill exposing the following:

(b) Section in Sec. 17, T. 8, R. 22, E. Pike County.

1. Orange sand (Lafayette).....20 feet.
2. Nanafalia Group..... 5 feet.
3. Yellow sands with laminæ of gray clay. The sands are somewhat cross bedded.....10 feet.
4. Green sandy clay, massive and weathering purple.....15 feet.

The thickness of this group in the vicinity of Brundidge I think is about 100 feet.

Near the plantation of Dr. Jno. A. Reynolds, in S. W. ¼ of Sec. 16, T. 9, R. 24 E., the clays encountered in digging the Brundidge well come to the surface and present very much the appearance of the calcareous clays seen near Sparta, Conecuh county, being however, somewhat more sandy.

(c) Section in S. W. 1-4 Sec. 16, T. 9, R. 24 E.

1. Gray, laminated micaceous clay, slightly calcareous. Resembles in appearance the clays in the vicinity of Jackson, Miss. It holds rounded masses of purer clay containing numerous silicified shells (too obscure to be identified) and some sheets of opalescent silica along the bedding planes.....20 feet.
2. Limestone with silicified fossils..... 6 feet.
3. Calcareous sand.....12 feet.
4. Coarse yellow micaceous sand.....25 feet.

Between Clayton and Louisville there is probably the most eastern outcrop of the clays constituting this group. A gully shows the following section:

(d) Section on Clayton and Louisville Road.

1. White chalky looking clay, gray when wet or freshly exposed.....15 feet.
2. Sandy limestone, such as occurs at Clayton and Troy...10 feet.

Mr. Monroe Warren, of Clayton, tells me that these clays are seen in all of the gullies in this vicinity.

While the soils of the section of country in which the members of this series outcrop are rather peculiar, they are mingled to such an extent with the soils derived from the

underlying rocks, that it is not practicable to separate them, so they will be treated of in the succeeding chapter.

The Midway (Clayton) Series.

General Discussion.—Probably the most important rocks of the Tertiary formation seen east of Butler county, are to be found in the lowermost or Midway Series. West of the Alabama River it does not enter either into the surface or rock forming constituents of this state, but occurs again in Tippah county, Miss.*

The Midway series may be sub-divided into two groups, differing from each other materially in organic remains and in lithologic character. The uppermost stratum is calcareous, varying in composition frrom a pure crystalline limestone (as seen in Little Texas, Butler county,) to a sandy calcareous clay at Midway, on the Alabama River, but always easily identified by the large Nautilus *(Enclimatoceras Ulrichi)*, White, the occurrence of which has led to the name Nautilus Rock, adopted by the Survey to designate this stratum. The lowest stratum does not occur on the Tombigbee or Alabama River, being first seen in the eastern part of Wilcox county, near Oak Hill.† It is a hard brownish yellow limestone, containing much sand in sharp grains and calcitized casts of shells, among them *Turritella Mortoni*, Con., *Venericardia planicosta*, Blain, and *Ostrea compressirostra*, Say.

Sections.—In the vicinity of Rutledge, Crenshaw county, Patsaliga Creek cuts through a white limestone at the

* An examination in 1885 of the fossils in the cabinet of the University of Mississippi leads me to the opinion given above, I found, however, that Dr. Hilgard refers both members of this group to the Cretaceous, in spite of the fine calcitized specimens of *Turritella Mortoni* Con. found in such abundance in the lowest stratum of the series (whence the name of Turritella Rock adopted by Smith & Johnson in Bull. 43, U. S. Geolog. Survey.) *Enclimatoceras Ulrichi*, white was found labeled "*Nautilus Circulus*, Tuomey, from wells near Ripley, Miss."

† See Oak Hill Section, Bull. 43, U. S. Geolog. Survey, 1887.

county bridge S. W. ¼ of N. W. ¼ Sec. 26, T. 9, R. 17 E.) on the Greenville Road. The rock is about as hard as ordinary orbitoidal limestone and of the same general appearance. Though it comes to the surface at intervals for a half mile east of the bridge, it seems neither to have any effect on the loamy soil, nor to make soil itself.

The few fossils seen are of such a character as to be of little assistance in determining the exact position of this stratum; those occurring are a small branching coral, *Gryphæa vomer*, Mort, and an *Umbrella?* At the quarries in the S. W. ¼ of Sec. 35, T. 9, R. 17 E., this rock shows about eight feet thick above the level of Patsaliga Creek, and makes the creek bed at that point. Here it is worked with crosscut saw and plane, after the manner of the orbitoidal limestone, and like it, finds extensive use as chimneys for the neighboring farm houses. That quarried below the water level has, when first exposed to the air, a bluish tinge, which is soon lost. Occasional pieces of pyrite are found, always bright and shiny. This limestone is peculiar to Butledge, and no outcrop has yet been found further than two miles in any direction from the town, though the numerous limesinks beginning on the west near the Butler and Crenshaw county line, and extending eastward about three miles from Butledge, and about the same distance towards the south, mark its extent and presence. This rock, from its relations to the Nanafalia group, may be referred to the Midway Series, and in all probability is the last remains of the Nautilus rock bearing a closer lithological resemblance to that stratum than anything in this part of the Tertiary. The fine dust and "waste" from the quarries is burned, and found to make an excellent lime, while much of it is stirred with water and applied as whitewash without any previous preparation.

Next to claim our attention, and the last of the Tertiary Rocks is the Turritella limestone and its eastward extension. As was said before, this rock makes its first appearance in the eastern part of Wilcox county. In the Oak Hill section it is seen to be only about five feet thick and is comparatively

an insignificant rock. Eastward it increases in importance and thickness. Evidences of this are seen in the hills south of Bragg's Store, Lowndes county, and along Cedar creek, where it is about ten feet thick and has a marked effect on both soil and topography. Its exact point of crossing the Louisville & Nashville railroad has not yet been determined, but it is believed to be somewhere near Searcy Station, between Ft. Deposit and Greenville. After leaving the railroad, going towards the east, the first outcrop is seen near a mill in the N. E. ¼ of the S. W. ¼ of Sec. 8, T. 10, R. 17 E.; no thickness could be determined at this point. In the S. E. ¼ of Sec. 12, T. 11, R. 19, the limestone again comes to the surface, and here its relation to the underlying Cretaceous rocks can be seen. A section gives the following:

(*a*) *Section in S. E. ¼ Sec. 12, T. 11, R. 19, on Mr. Beltzer's place.**

1. Gray argillaceous and slightly calcareous sand holding an occasional shell cast.....10 feet.
2. Argillaceous limonite from a bed of decomposed greensand, containing numbers of obscure shell casts.....2 feet.
3. Light yellow calcareous sands.....20 feet.
4. Limestone, hard and containing much sand was seen on the tops of hills and is probably thicker than.....2 feet.
5. Yellow, highly micaceous sands.....60 feet.
6. Argillaceous sandy gray limestone, holding *Exogyra costata*, Say.....4 feet.
7. Gray micaceous sands.....6 feet.

Much of this limestone has been burned for making quick lime; and some little of this put on the land. Kilns have been erected out of the ferruginous sandstone found in the Lafayette and the lime burnt, so I am told, for about 12½ cents a bushel.

E. Q. Thornton† mentions a white limestone cropping out in the bed of Conecuh river, from underneath a stratum of fossiliferous sandstone. The limestone, which he says is

*If the limestone, No. 4, be as Mr. Langdon conjectures, the Clayton limestone, it is an outlying area. It seems, from its position, to be more probably a member of the Ripley Cretaceous.—E. A. S.

†Second Bienn. Report on Geolog. of Ala., M. Tuomey, p. 244, 1828.

nearly pure carbonate of lime, crops out on the hills toward the north, and is burned for making quick lime; this is most probably the Troy limestone, as many old kilns were seen in the vicinity of Pottersville P. O., Pike county, about Sec. 30, T. 10, R. 20.

In the gullies so numerous about Troy, this limestone may be seen cropping out. Near the pump-house the following section is seen:

(*b*) *Section at Troy, Pike County.*

1. Light yellow, micaceous sands, (seen south of town on crossing the first creek).....50 feet.
2. Gray, glauconitic micaceous sand, containing a few fossils mainly concentrated about the indurated layers that occur throughout this stratum. The sand is somewhat calcareous. The only fossil recognized was *Gryphæa vomer*, Mort.....30 feet.
3. Cream colored, sandy limestone, full of obscure shell casts, among them *Rostellaria velata*, Con.; *Venericardia planicosta*, Blainv.; *Venericardia rotunda*, Lea.; *Corbula oniscus*, Con.: *Gryphæa vomer*, Mort.....20 feet.
4. Gray calcareous clay, no fossils seen.....6 inches.
5. Sandy gray clay passing into a very coarse grained sand unfossiliferous.....4 feet.

This limestone, No. 3 of the above section, crops out again in the N. W. ¼ of Sec. 1, T. 9, R. 22 E., and is found in wells at Brundidge, about ninety feet from the surface. Crossing Pea river near the mouth of the East Fork it makes the river bed to within two miles of the Dale county line. At Dr. Jno. A. Reynolds', in Barbour county, we have:

(*c*) *Section in S. W. ¼ of Sec. 16, T. 9, R. 24.*

1. Gray laminated clay, micaceous and somewhat calcareous. Resembles the gypseous clays of Jackson, Miss., in appearance but is more sandy. Rounded masses of purer clay containing numerous silicified shell casts occur throughout this stratum while along the joint planes are thin sheets of opalescent silica.....20 feet.
2. Light colored, almost white limestone, forms in the gully a projecting ledge. The upper part is very hard, almost crystalline, while all of the shells except the *ostrea* are silicified. Fossils:

Serpula, Sp?; *Turritella carinata?* Lea.; *Nucula magnifica*, Con.; *Cardium divisurum*, Con.; *Venericardia planicosta*, Lam., and *Ostrea compressirostra*, Say.....6 feet.

3. White and light yellow calcareous sand containing numbers of large *Ostrea compressirostra*, Say., and many obscure casts; *Rostellaria velata*, Con.; *Trochita trochiformis*, Lam., and *Turritella carinata?* Lea., were identified.....12 feet.
4. Coarse yellow, micaceous sands, slightly glauconitic. Contains a few small oysters and some unrecognizable casts. Weathers dark red.....25 feet

Eastward this rock is next encountered at King's Bridge over Lindsey's creek in the N. E. ¼ of Sec. 21, T. 9, R. 26, where it is seen about twenty-five feet thick. The lower part is cream colored and presents the appearance of having been possessed of a coralline structure, the organic structure being now nearly obliterated by atmospheric agencies, while the upper six or eight feet is chocolate brown in color and somewhat cherty in character. This rock has been burned for quicklime with much success, the harder portions being particularly adapted to that purpose.

The locally celebrated Blue Springs in the S. W. ¼ of the S. E. ¼ of Sec. 14, T. 8, R. 25, flow from fissure in this limestone. The fissure extending about a hundred and fifty yards north and south may be traced by the depressions in the swamp. The water is a delicate blue in color, very limy and flows off at the rate of about 150 gallons a minute. It is possessed, too, of much curative power, either real or imaginary. Here the close relation to the Nanafalia group can be traced, since in an old field in the N. W. ¼ of the N. E. ¼ of Sec. 15, T. 8, R. 25 E., the buhrstone-like phase of that series is found, the elevation above the spring being scarcely a hundred feet. In Sec. 14, T. 8, R. 25, there are numbers of lime-sinks.

At Clayton and vicinity this hard, sandy limestone is found in the gullies toward the south of town and I am told is sometimes encountered in the wells. It is full of a species of oyster* closely resembling the one found associated with

Ostrea tumidula, Aldr.—E. A. S.

Enclimatoceras Ulrichi, White, in Butler county. Some of the more progressive farmers have burned it for use in farming operations, doubtless with good results. Two miles east of Clayton this rock may be seen cropping out in a cut on the Clayton & Eufaula Railroad. No inland outcrop has been examined east of this, though doubtless many occur.

On the Chattahoochee river this is the most prominent Tertiary rock, showing there a thickness of about three hundred feet and extending vertically from the Cretaceous to the Nanafalia series. The section there exposed would be:

(*d*) *Section of Midway Series exposed along Chattahoochee River.*

1. Light yellow limestone filled with casts and a few large *Ostrea compressirostra*, Say. (var.) Large irregular pockets of white sand, inclosed in black clay, occur in pot holes throughout the stratum.....20 feet.
2. White calcareous sand, containing a few casts and now and then a large *Ostrea compressirostra*, Say. This stratum is the source of many lime springs and contains occasional indurated ledges.....180 feet.
3. Light yellow silicious limestone containing large *Ostrea* and numerous small casts; only the lowest ten feet seen, but estimated at.....90 feet.
4. Massive conglomerate; matrix calcareous, pebbles, silicious and waterworn.....8 feet.

The upper surface of No. 1 is very irregular and the superincumbent Nanafalia beds rest in a manner unconformably upon the eroded surface, showing that its surface had suffered denudation before the deposition of the *Gryphœa thirsœ* beds. This stratum forms the base of the bluff at Ft. Gaines, Ga., opposite Franklin, Ala. Analyses by the State Chemist of Georgia, show the presence of from 1½ to 2 per cent. of Phosphoric Acid, which would make it of much value for agricultural purposes.

Dr. R. H. Loughridge, formerly of the State Geological Survey of Georgia, gives the following section of the bluff at Ft. Gaines.

(*c*) *Section at Ft. Gaines, Ga.* (After Loughridge).*

1. Red loam.....50 feet.
2. Layer of Ostrea compressirostra (?).....18 inches.
3. Light yellow clay marl with a few broken fossils.....15 feet.
4. Blue compact pyritous clay.....8 feet.
5. Same with casts of fossils.....2 feet.
6. Blue fossiliferous and compact clay marl.....25 feet.
7. Clay with nodules.....4 feet.
8. Yellowish shell marl.....3 feet.
9. White friable limestone or marl with ledges of limestone disappearing below the water.....15 feet.

No. 9 of the above section Dr. Loughridge erroneously took to belong to the Claiborne group.

As a source of soils, this division of the Midway series has a most important bearing on the farming industries of this section of Alabama. Soon after crossing the Crenshaw-Butler county line on the Greenville-Rutledge road, the observer is struck with the fertility of the deep red lands apparently too sandy to be productive, but found by experience to be highly so. This strip of red lands continues on into Barbour county, passing in its northern limits through Honoraville, Troy and Monticello, while its southern boundary is marked by a line drawn from a point two miles south of Rutledge, through Hallsville and Brundidge. In other words, to speak generally, it is embraced in Townships No. 9 and No. 10, ranges 17 to 24 inclusive, comprising the finest farming lands in Pike county, and among the best in the state. This soil contains enough lime to produce grass crops well, enough sand to make its proper drainage easy, and enough clay to prevent damage from drouth. The greater part of these lands have been cleared so that it is seldom that enough primeval forest can be seen to determine the character of the original vegetation. The growth is red, white and Spanish oaks, dogwood, and black gum, with an occasional short-leaf pine, all hung with the gray moss (*Tillandsia usneoides*) indicative of a calcareous soil.

*Report on Cotton Production of Ga., 10th Census, VI, p. 14.

The useful materials of this series have been treated of with the localities *seriatim*.

Summary of the Variations in the Tertiary Strata East of the Alabama River.

An examination of plate XXIX will show the variability of the sub-Nanafalia series to the ultimate disappearance on the Chattahoochee of all the strata between the Nanafalia series and the Turritella rock, a thickness, as represented on the Tombigbee river, of 250 feet. It will be seen, too, that this disappearance is gradual and is accompanied with the interpolation of several distinct series of limited extent, the most notable of which is the uppermost of the Midway series. This stratum, known as the Nautilus Rock, from the most abundant fossil (*Enclimatoceras Ulrichi*, White), is first found at Midway Landing on the Alabama river, about four miles below Prairie Bluff. In this locality the rock is a gray calcareous sandy clay, while at Oak Hill, Wilcox county, about twenty miles distant, it is a white argillaceous limestone of about the same composition as the Rotten Limestone of the Cretaceous, and in Little Texas, in the corner of Lowndes, Wilcox and Butler, twenty miles still further east, it is a nearly pure crystalline carbonate of lime. The thickness varies, too, as much as the composition, being fifteen feet on the Alabama, ten feet at Oak Hill, and forty feet in Little Texas, east of which place it has not been traced with any degree of accuracy, though there is good reason to believe that it reaches its highest development in the last named locality. The lowest member of the series, the Turritella Rock, is first seen at Oak Hill where it is but five feet thick. This increases to eight feet in Little Texas, fifty-five feet at Troy, eighty feet at Brundidge, a hundred and twenty feet in southwest Barbour county, along Pea river, and to three hundred feet along the Chattahoochee river. In general character it changes but little, being somewhat more silicious towards the east and holding on the Chattahoochee ten feet of conglomerate at the base.

On the Tombigbee river the Midway deposits have no place, the strata next above the Ripley group of the Cretaceous, being the black laminated clays, best developed at Black Bluff, and amounting to about one hundred feet in thickness. Those on the Alabama river become more calcareous and dwindle down to about forty feet, while at Oak Hill they contain a still greater percentage of lime and decrease to a thickness of twenty-five feet, disappearing entirely a short distance east of Monterey, Butler county.

The Matthews's Landing or Naheola series, characterized by gray and light yellow clays interstratified with cross-bedded sands, sometimes glauconitic, and holding in its lowest twenty feet fossiliferous strata containing many peculiar species, is more constant in its thickness and more extensive in its distribution than the Black Bluff section just referred to. On the Tombigbee the succession is not altogether complete, except of course relatively, but is estimated at one hundred and thirty feet, while on the Alabama the estimated thickness is ten feet less. At Oak Hill this series in its fossiliferous character reaches its maximum development, while in thickness it has increased to one hundred and ninety feet. Disconnected outcrops are seen at Wolf creek in Sec. 34, T. 11, R. 13, and in the outskirts of Greenville, but east of the latter place it loses its character as a marl bed, and is represented by a series of interstratified cross-bedded sands and laminated clays which entirely disappear before reaching the Chattahoochee river.

The Coal Bluff series, or that portion of the Tertiary formation below the Nanafalia group and above the Coal Bluff lignite, inclusive, is represented on the Tombigbee river by seventy feet of strata consisting in the main of cross-bedded sands and thin-bedded gray sandy clays underlaid by ten feet of lignite. The Alabama river exposes seventy feet of the sands and clays as described above, and five feet of lignite, while Oak Hill and the Grampian Hills of Wilcox county show only sixty-five feet of strata including the five foot seam of lignite.

At Oak Hill, Sec. 16, T. 11, R. 10 E., Wilcox county, the Matthews's Landing and Coal Bluff series combined give a thickness of two hundred and sixty feet, while at Troy they are embraced in one hundred and twenty-five feet; at Brundidge, Pike county in ninety feet; and at Mr. Messix's, Barbour county, Sec. 26, T. 8, R. 23, within the limits of about eighty feet.

The character of the country east of the Louisville & Nashville Railroad is such as to render it difficult to find natural sections and to determine the thickness of the Tertiary rocks, this being particularly the case as regards the Post-Nanafalia series. The only inland evidence of the general eastward thinning out relative to the upper members of the Lignitic Group is seen near Sepulgah, Conecuh county, where in Sec. 27, T. 9, R. 10 E. the distance between the Wood's Bluff marl and the bottom of the Buhrstone is only one hundred feet while on the Tombigbee River it is nearly twice as much. The hypsometric relation on Pea River, between the Wood's Bluff and the Buhrstone, was found to be about twenty five feet, while on the Chattahoochee River it is only ten feet.

THE CRETACEOUS FORMATIONS.

In that part of Alabama drained by the Alabama, Tombigbee and Tuscaloosa rivers, the Cretaceous formation is represented by four groups, the Ripley, the Rotten Limestone, the Eutaw and the Tuscaloosa, each differing more or less from the other, either in lithologic or paleontologic character. These differences have been enumerated and described by Dr. E. A. Smith* some time since, so that any elaboration here is unnecessary. Of these four groups only three of them are persistent throughout East Alabama, the Rotten Limestone not appearing in the drainage of the Chattahoochee River. The Ripley, in West Alabama the most

*Bull. 43, U. S. Geolog. Survey, p. 71 et seq., 1887.

insignificant in thickness and surface extent, becomes the most important group, while the Eutaw and Tuscaloosa lose few if any of their characteristic features, the latter group, however, being somewhat thinner than in the regions heretofore examined. It is much to be regretted that only a partial study has been made of the outcrops of the Ripley and the Eutaw Groups so that our information of the inland exposures of the rocks of these two members of the Cretaceous is but meagre. The greater part of the Cretaceous area of East Alabama is covered by thick beds of Lafayette, so much so in fact, as to prevent any marked influence on the soil by the calcareous strata of this formation, while in West Alabama the finest farming lands are the direct products of the disintegation of Cretaceous rocks.

The southern boundary of this formation has been marked with much accuracy as regards the region under consideration, by Dr. Smith in his Geological Map, published with Berney's Handbook in 1878; the few corrections necessary have been made for the map soon to be published.*

The Ripley Group.

This uppermost member of the Cretaceous formation consists, in this part of the state, of gray micaceous sands, somewhat calcareous and containing occasional strata of silicious limestone more or less phosphatic in character. As yet none of these limestones have been found to contain sufficient phosphoric acid to make them of economic value, or of any particular importance, even to the adjoining farms. In the upper measures of this group there is found a limestone, which on casual examination, particularly if it be unfossiliferous, as is frequently the case, may be confused with the last of the Tertiary strata. A more critical study of this stratum and a direct comparison with its Tertiary cogener,

*See the Geological Map of Alabama with Explanatory Chart, 1894. E. A. S.

shows the Cretaceous rock to be more aluminous and to contain fewer and less sharp grains of sand. As these two indurated strata are within sixty feet of each other in the vicinity of Troy, and as both are frequently unfossiliferous it is well to observe these differences in chemical and lithologic composition. It was no doubt the occurrence of similar strata that caused Dr. Hilgard* to refer both members of our Midway or Clayton series to the Cretaceous formation. In lieu of natural sections in the interior I shall mention first the succession of strata referable to this group on the Chattahoochee and endeavor to draw some parallels with inland outcrops. As was stated above, we do not have any representative of the Rotten Limestone in the westernmost drainage of the state,† so that the Ripley group rests directly upon the Eutaw. Geographiclaly the Ripley extends from Fitzsimmon's Landing on the Chattahoochee, just below mouth of Ihagee creek, down to a point midway between Otho and Fort Gaines, about Sec. 17, T. 8, R. 29 E. an approximate distance of forty miles. In thickness a summing up of the strata exposed along either bank of this river and noted with much care, gives a thousand feet, while in the General Section of Smith‡ it is only two hundred and seventy-five feet.

In detail this section is:

[illegible]

[illegible] feet.

[illegible] 25 feet

[illegible]

[illegible]

[illegible]

3. Gray sand with indurated ledges, no fossils seen; merges gradually into a dark gray almost black sand, containing large nodular masses which become in its uppermost part interstratified with light yellow sands.....35 feet.
4. Hard, sandy ledge, weathers to a jagged surface. Very light yellow, almost white when dry, and unweathered. Contains *Exogyra costata*, Say., and echinoids.....30 feet.
5. Light yellow sand, interstratified very irregularly with a gray micaceous sand filled with Ripley fossils too friable to collect. At water's edge, mouth of Pataula Creek.....30 feet.
6. Brown, laminated, argillaceous sand..... 5 feet.
7. Massive, gray sand, containing bowlders.....35 feet.
8. Gray fossiliferous sands..... 5 feet.
9. Yellow crossbedded sands with indurated ledges filled with casts and *Exogyra costata*, Say, and a few echinoids. Some thin lignitic streaks occur.....35 feet.
10. Calcareous gray sands with boulders.....50 feet.
11. Light yellow, cross-bedded sands enclosed between indurated ledges.....20 feet.
12. Calcareous gray sand, filled with *Exogyræ* and many indurated ledges. This stratum causes the first shoal below Eufaula.....70 feet.
13. A massive, gray sand, containing a few fragile fossils, and some rounded bowlders. This sand is but slightly calcareous and is more or less lignitic. The dip at this point is above normal, being about 100 feet to the mile. This stratum forms the bluff at the mouth of Barbour Creek.....40 feet.
14. Light gray or yellow sands interlaminated with argillaceous sand, darker in color and containing bits of lignitized leaves and twigs, no other fossils seen.....20 feet.
15. Gray, calcareous sand, with indurated ledges; becomes more sandy in upper part. Fossils: *Exogyra costata*, Say; *Hamulus onyx*, Mort; *Gryphæa vesicularis;* Lam; *Plicatula urticosa*, *Anomia*, Sp?.....125 feet.

This forms the bluff at Eufaula. A north dip is seen just above the steamboat landing, while below the railroad bridge the normal south dip occurs, the bluff forming the axis of a small anticline involving some thirty feet of strata. Frances' bar, just above Eufaula, is caused by the indurated ledges of this stratum.

16. Soft, rather incoherent sand, gray in color, makes its appearance at the mouth of Cowikee creek, where about a hundred yards above the junction with the river it rises fifty feet above the water level.....60 feet.

17. Gray, glauconitic, calcareous sand, containing indurated ledges about a foot thick. These ledges show the dip to average about forty feet to the mile, and mark several slight undulations occurring in the adjoining strata; dips below the river just above Cowikee creek ... . 170 feet.
18. Gray fossiliferous marl, the shells too fragile to collect. Holds an occasional lignitized log and numerous nodular fossiliferous masses.....5 feet.
19. Gray, glauconitic calcareous sand, weathering into fucoidal surfaces and containing an occasional soft white nodule, phosphatic?.....10 feet.
20. Gray, highly fossiliferous marl, weathering red. The shells are mostly in fragments, and are intermingled with bits of lignite..... .....2 feet.
21. Cross-bedded gray sands and clay.....15 feet.
22. Indurated sandy stratum containing *Ostreæ*.....1 foot.
23. Very highly fossiliferous gray marl, the shells being nearly all bivalves and mostly comminuted. Numerous sharks' teeth and a hard black substance which looks as if it might be the under shell of a turtle, occur, associated with black coprolitic pebbles and numerous bits of lignite.....3 feet.

Nos. 19 and 23 inclusive occur on the east bank of the river, about five miles below Florence, Ga.

24. Gray and yellow sandy clays, laminated and bearing a close resemblance physically to the Tertiary strata at Lower Peach Tree, on the Alabama River..... .....30 feet.
25. Gray calcareous sands, containing a small fragile *Anomia* and a line of hard rounded bowlders .....40 feet.
26. Gray sand, interlaminated with thin seams of more argillaceous sand, unfossiliferous.....26 feet.

This Stratum, with a part of the one overlying, makes up the bluff at Florence, Ga.

27. Gray sandy calcareous clay, with bowlder-like concretions, projecting in a line from the bank. First seen about a mile above Lawson's Woodyard, Ga. Few fossils seen; none, in fact, except a small *Exogyra*, until a mile above Blufftown, Ga., where the characteristic Ripley shells occur in profusion throughout a stratum some six or eight feet thick. The fossils are, however, too fragile for collecting without being soaked in glue; bivalves predominate. The river washes out little cave-like recesses in this stratum. At Jernigan Landing, Barbour county, undulations involving some twenty feet of strata occur; these rolls continue to within two miles of Florence, Ga. The upper ten feet of this stratum is highly fossiliferous. It is impossible to "count up" its exact thickness, but after averaging dips, it is estimated at....120 feet.

As has been stated above, there are evidences of disturbances, although slight, all through the time following the deposition of the Ripley strata. These undulations, gentle as they are, cause an abnormal outcrop along the river. The exact age of these disturbances is not clearly indicated, but taken in connection with the Moscow faults and folds in strata of the same group, they form an interesting geological fact.

At Collirene, Lowndes county, an examination was made of the peculiar shaped hill described and figured by Prof. Thornton.* The following is the section:

(*b*) *Section at Collirene, Lowndes County.*

1. Pebbles (Lafayette).....15 feet.
2. Calcareous sandy conglomerate.....5 feet.
3. Micaceous sand, bluish gray, unfossiliferous.....105 feet.

The conglomerate, Stratum No. 1, forms a projecting ledge all around the hill, causing a peculiar mushroom-like appearance. This stratum is the same that occurs near Carlowville, Dallas county,† and consists of a mass of sand and calcite *nuclei* of shells cemented together by phosphate of lime.

The micaceous sands, Stratum No. 3, resemble very closely the dark colored sands found near Dayton, Marengo county, and are probably the same.

This hill, known locally as "The Mount," is about a mile from the village of Collirene.

At Collirene, the Hayneville road gives the following section on a hillside:

(*c*) *Section at Collirene, No. 2.*

1. Lafayette, mainly pebbles.....25 feet.
2. Micaceous sands, containing some lime and some clay. The uppermost portion of these sands is mottled like some Lafayette clays, the next is oxidized to a bright yellow color, while the lowest is blue gray and contains a few univalve casts...70 feet.

*Second Bienn. Rep. Geol. of Ala., p. 234, Fig. 35, 1858.

†Smith, Bull. 43, U. S. Geolog. Survey, p. 82, 1887.

Four miles south of Collirene, on the Crook plantation, the soil assumes a regular prairie character. The country-rock is a cream colored calcareous clay containing phosphatic concretions, casts of shells, &c., similar to those found near Dayton, Marengo county. The concretions are in shape coprolitic, and consist of a soft cream colored exterior and a hard black micaceous nucleus which is sometimes fossiliferous. A well on the plantation gives the following:

(*d*) *Section in Sec. 36, T. 14, R. 12, E., Lowndes County.*

1. Surface soil.....2 feet.
2. Light blue, argillaceous limestone, forming the basis of the stiff prairie lands in the adjoining fields.....20 feet.
3. "Hard sand rock," in all probability the conglomerate which forms the capping to "The Mount" in the last section.

The disintegration of the matrix rock, Stratum No. 2, of the above, gives rise to a red waxy soil, which wears out very quickly, but is easily restored to its former fertility by turning under green crops. The occurrence of the conglomerate in this elevation would indicate a dip of about 40 feet to the mile, thus accounting for its absence on the Collirene Hill.

That section of the state between Collirene, Lowndes county, and Helicon, Crenshaw county, has not yet been examined, but it is hoped that another season will put us in possession of all obtainable information concerning that area.

In the S. W. ¼ of S. W. ¼ of Sec. 1, T. 11, R. 19, the first unquestionable Cretaceous rocks are found, traveling from the Tertiary region to the southward. Here there is:

[illegible]

1. [illegible] 15 feet.
2. [illegible] 9 feet.
3. [illegible] 4 feet.
4. [illegible] 4 feet.

At this point the indurated ledge has become so much weathered as to form a soft pulverulent marl that might be applied with benefit to the adjoining sandy lands.

This same stratum of limestone, No. 2, of the last section, crops out in the N. W. ¼ of Sec. 36, T. 12, R. 20, near Orion, Pike county. At this locality it is made up of two or three indurated ledges eighteen or twenty inches thick, enclosing a softer cream colored material of approximately the same composition. The ledges contain some quantity of phosphate nodules, and are admirably situated for burning. A kiln could be constructed of the Lafayette sandstone found in abundance in the adjoining hills and the lime burned, according to the estimate of a gentleman of some experience with whom I examined the outcrop, at ten cents per bushel. The neighboring sandy lands might be materially benefited by the application of this natural fertilizer and much of the present waste on farms particularly the refuse from the cane mills could be utilized in composts.

On Patsaliga creek, Crenshaw county, in Sec. 1, T. 11, R. 18 E., there is an outcrop of a bluish gray sandy phosphatic limestone, rather soft, and containing a few large *Exogyra costata*, Say. Some small grains of dark colored phosphatic material occur throughout the mass. This marl would be of inestimable value to the neighboring worn out sandy land of which there is an abundance. From this point on through the southern part of Montgomery county the topography presents a series of hills made up of the micaceous calcareous sands of the uppermost Cretaceous, with here and there a strip of stiff "mulatto" land, resulting probably from less sandy strata of limestone. In the vicinage of Pine Level, Montgomery county, the Cretaceous strata bear a close lithologic resemblance to the Eutaw sands. The yellow cross-bedded arenaceous beds continue for a few miles and are succeeded by a strip of "mulatto" land five miles wide and extending to the Catoma creek swamp in Sec. 36, T. 14, R. 19. Here ends the Ripley group in this direction.

The road from Orion to Perote via China Grove passes over the gray micaceous sands of the Ripley group. None of these sands contain any other fossils than a few obscure casts. An occasional indurated ledge of yellow sandy clay containing more lime than the sands, causes a striking resemblance to the Bridgeport shales. These shaly ledges may be seen about two miles west of Orion as well as in this easterly direction. From China Grove, Pike county, toward Farriarville the road passes for several miles along the outcrop of some black, laminated sandy clays, resembling very closely a phase of the Black Bluff, Tertiary series. All doubt as to their age was dispelled by the occurrence of a stratum containing *Exogyra costata*, Say., seen overlying the clays, which are themselves unfossiliferous. The exact analogue of this deposit I have not seen before nor can I refer it to any specific horizon in the Ripley Group. The most that can be said of it is that it is Cretaceous and most probably Ripley. Between Perote, Bullock county, and Clayton, Barbour county, the beds of Lafayette prevent any extensive outcrops of a Cretaceous age, the few occurring, being the indefinite gray micaceous sands peculiar to the Ripley.

The Rotten Limestone Group.

East of the drainage of the Alabama River the Rotten Limestone such as occurs in Marengo, Perry, Dallas, Lowndes and Montgomery counties, is not represented. The exact eastern limit of this group has not as yet been determined, but evidences of its decreasing thickness are seen in the narrow outcrop in the neighborhood of Pike Road, Montgomery county, where its north and south extent is only five miles as contrasted with thirty miles in Dallas county. Further than this decrease in thickness our present information does not warrant us in saying anything. As has been stated before no rocks bearing any lithologic resemblance to the Rotten Limestone have been seen on the

Chattahoochee River, whether or not this group is represented by strata of different composition from the typical aluminous limestone we are not in position to say, since no critical examination of the fossils of the several divisions of the Cretaceous has yet been undertaken. It is much to be regretted that the divisions have been of necessity made on such arbitrary grounds as mere lithologic differences, since marked variations can be noted in almost any stratum of any of the groups, and experience in both the Tertiary and Cretaceous of Alabama has proved the risk of creating groups on any but combined physical and faunal differences.

The Eutaw Group.

One of the most characteristic exhibits of the Eutaw Group, away from the typical locality, may be seen within the city limits of Montgomery in the deep cuts of the Montgomery & Eufaula Railroad. The cross-bedded, slightly glauconitic yellow sands are strongly developed and are about twenty feet thick. The Eutaw continues along the railroad until reaching Oak Grove, nine miles south of east of Montgomery, where the first of the Rotten Limestone appears. The road from Pike Road, Montgomery county, to Tallassee, Elmore county, crosses a belt of stiff yellow lime lands about a half mile wide and lying between outcrops of Rotten Limestone and Eutaw. This is altogether unlike anything I have yet seen, and I am in some doubt whether this soil is derived from a sandy phase of the Rotten Limestone or a Calcareous stratum of the Eutaw Sands; this is about two miles north of Pike Road. Near Dreyspring, Montgomery county, the last undoubted outcrop of Eutaw occurs, making the geographical extent of the outcrop about six miles, as contrasted with nine miles in Greene county at the typical locality.

On the Chattahoochee there are three hundred and fifty-five feet of strata referable to this group, extending from

Broken Arrow Bend, eight miles below Columbus, down to Fitzsimmons' Landing, which is just above the mouth of Ihagee Creek. On this river, as on the Alabama and Tombigbee, the group is characterized by the cross-bedded yellow sands and gray laminated clays, virtually devoid of any organic life. In detail the strata in chronological order are:

(a) *Section of Eutaw strata on the Chattahoochee River.*

1. Light yellow and white sands, containing beds of quartzose pebbles sometimes twenty feet thick. Lignitized logs are seen protruding from the bank. At rare intervals a small *Exogyra* sp.? occurs.....45 feet.
2. Yellow sands and gray clay containing bits of leaves. At a distance this clay has much the appearance of lignite. The sands and clays are strongly cross-bedded, the clay being frequently deposited along the bedding planes.....60 feet.

   The last two strata make up the celebrated Chimney Bluff, the highest prominence between Columbus and Eufaula. Chimney Bluff is twenty-three miles from Columbus, Georgia, by river.
3. A heavy quartzose conglomerate, similar to the one occurring in the Tuscaloosa Group near Havana, Hale county,* forms the shoal at Beden's Rock and the Bluff at Hatcher's Lower Landing, about twenty miles by river, below Columbus, Georgia, merges gradually into a yellow sand.....50 feet.
4. Yellow and white sands with thin seams of lignitic sand and an occasional lenticular mass of gray laminated sandy clay. This stratum is best developed in a bluff about 100 yards east of the river bank just south of Rooney's Mill Creek.....50 feet.
5. Laminated, dark gray clays, with masses of yellow sand distributed at irregular intervals throughout the stratum. Best developed just above Uchee Creek, Russell county.....25 feet.
6. Gray calcareous sand, containing in the lower portion a few friable specimens of *Exogyra densata?* Con. The upper part becoming more argillaceous is laminated and unfossiliferous. This stratum strongly resembles in the uppermost fifty feet the Black Bluff clay of the Tertiary, except that in color it is brownish gray, and like the Tertiary rocks causes landslides. This stratum forms the greater part of Uchee Shoals.....100 feet.
7. Dark gray calcareous sand, pyritous and containing nodular masses 6 to 12 inches in diameter, holding calcite in the center

*Smith's Bulletin No. 43, U. S. Geol. Survey, p. 111, 1887.

after the manner of the Bell's Landing bowlders. These nodules are arranged in strata about two feet apart and terminate in an indurated stratum about a foot thick. Small fragments of lignite are scattered through this entire stratum and one or two large masses filled with calcitized *teredos* were found. The only fossils seen were an *Anomia* sp.? and an Exogyra (Either *E. densata* or the young of *E. costata*, Say.) The fossils were all poorly preserved. Dip, as indicated by the strata of the nodules and the indurated stratum, 40 feet to the mile.....15 feet.

It is rather to be regretted that there are no bluffs exhibiting the contacts between this group and the Tuscaloosa on the one hand and the Eutaw and the Ripley on the other. The outcrops of both the underlying and the overlying groups are so close to the first and the last appearance of the Eutaw that the quantity of unnoted strata is small, if, in fact, there be any.

The Tuscaloosa Group.

The lowest of the Cretaceous strata so well developed along the Tuscaloosa River, where they rest immediately upon the Coal Measures, is found in the eastern section of Alabama to rest unconformably upon the Laurentian and Huronian gneisses and mica-schists. On the river from which this group takes its name, there are several beds of massive clay, and some thinner laminated beds containing leaf impressions.*

Towards the east these clay beds become less frequent, and the fossil-bearing strata do not seem to occur at all. The Lafayette-like character of these rocks has led to much confusion in the minds of geologists in time past, this feature being more marked in the Alabama and the Chattahoochee drainages than in either the Tombigbee or the Tuscaloosa. The geographical extents of the materials of this group are very accurately defined by both Tuomey† and

*Bulletin No. 43, U. S. Geol. Survey, p. 104, 1887.

†Second Biennial Report on Geology of Alabama, 1858.

Smith* in their published maps, the formation in both cases being referred to as Post-Tertiary, as it was universally considered at those times. As these two maps show, the most extensive development of this formation occurs in Chilton county near the Bibb county line. Here, as might have been expected, the strata are composed almost entirely of cross-bedded sands and silicious pebbles, since the rocks from whose disintegration this group is derived are the silicious crystalline rocks, aluminous rocks being uncommon. Whereas on the Tuscaloosa and Cahaba Rivers the proximity of the shales and slates of the Coal Measures in the first case, and the Knox shales in the other, afford abundant sources of supply for the extensive deposits of clay. Unfortunately the fossiliferous beds of this group are irregular in character and limited in extent, so that in most instances only an approximation of the thickness of this group can be ascertained. In West Alabama Smith+ estimates the thickness along the Tuscaloosa River at 1000 feet, evidences pointing to only 200 to 250 feet on the Chattahoochee, of which 60 or 70 are seen in the river banks, while in Chilton county it is probably thicker than anywhere else in the state. At Wetumpka, Elmore county, there is a thinning down of the strata to less than 50 feet, since the phosphatic deposits occurring at the base of the Rotten Limestone are found very near, within less than 100 feet of the Crystalline rocks which make up the bed of the Coosa River at that point. This locality needs further working up and it is rather an uncertain quantity at the present. On the Tallapoosa we have:

[illegible]

1. Recent beds, evidently from the lower agency of the Tallapoosa River, filled with pebbles, many of them weighing as much as ten pounds, the pebbles decrease in quantity in the upper

*Berney's Hand-book of Alabama, 1878.

+Bulletin No. 3, U. S. Geol. Survey, p. 18, 1887.

part of the stratum; rests conformably on the following.....20 feet.

2. Light yellow, slightly agillaceous sand, containing many well-rounded water-worn pebbles. Tuscaloosa Group.....15 feet.
3. Crystalline rocks, dipping N. N. W. about 30 degrees from the river bed.

About a mile below this outcrop at the Ferry, the white and red mottled sandy clays of this group show just above the water's edge.

One of the best sections of the Tuscaloosa Group exposed in East Alabama, is seen near old Ft. Decatur, in the N. E. $\frac{1}{4}$ of the N. E. $\frac{1}{4}$ of Sec. 20, T. 17, R. 22, E., viz:

(b) Section at Old Fort Decatur, Macon County.

1. Pebbles in light grayish yellow matrix. Pebbles rather small, mainly quartzose, but occasionally schistose.....6 feet.
2. Yellow coarse-grained sand, shading to light purple in color. Contains a few quartzose pebbles and bits of water-worn clay, the mass being but slightly argillaceous.....10 feet.
3. Purple and greenish micaceous sandy clay, with a few small quartzose pebbles. The upper and lower parts have a banded appearance.....12 feet.
4. Greenish and brownish highly micaceous sand, with dark colored grains of hornblende, or black mica; slightly micaceous and strongly cross-bedded.....8 feet.
5. Greenish and purple mottled sandy clay.....4 feet.
6. Yellow and gray coarse-grained sand.....4 feet.

It is very difficult to separate this outcrop into distinct strata as the beds are variable, both in thickness and in composition. A bed of coarse sand and pebbles will, in a hundred yards, be changed to mottled sandy clay, and the termination will be so gradual that it is next to impossible to distinguish the beginning of the one or the ending of the other. This is evidenced, by the following section, made about 100 yards east of the one just given, and representing the strata exposed in the cut on the Western Railroad and in the bank of the Tallapoosa River.

Mason, Mason County.

between argillaceous sand
more argillaceous than t
aceous appearance, mergin

fine-grained, micaceous sand
nodules and lots of green s
ossil bearing; there are occas
stone about 10 feet

(*d*) *Section of Tuscaloosa Group on Chattahoochee River.*

1. Strongly cross-bedded coarse sand and pebbles, with some fragments of mica schist, just enough white clay to make it hold together. The quartzose pebbles are all well water-worn, while the bits of softer schist remain but slightly abraded. The stratum varies in color from white to lemon yellow, and in places green, while the upper part becomes purple and yellow, variegated. This is best developed at Thomas' Bluff, Ga., where it is conformably overlaid by No. 2 and No. 3. Estimated at.....40 feet.
2. Red and gray variegated sandy clay, shows at water's edge at the month of Bull Creek, Ga.....5 feet.
3. Hard, white, coarse-grained sand, held together by white clay or finely divided silica.....15 feet.
4. Hard clay, stained with ferruginous matter; has conchoidal fracture.....1 foot.
5. Light green, highly micaceous sand, resembling weathered mica schist, and but for the occasional large water-worn quartzose pebbles, might be mistaken for schist.....3 feet.
6. Laurentian Gneiss at Columbus.

The Tuscaloosa Group seems to have appropriated materials from all the formations over which it is deposited. In Mississippi,* according to L. C. Johnson, the pebbles are mainly, if not entirely, of Sub-carboniferous chert, the same being the case in the vicinity of Tuscaloosa; the softer materials of the Coal Measures having been converted into sands and clays by the grinding action of the rapidly flowing currents. The few quartzose pebbles found in this group in this part of the state are in all probability derived from the disintegration of the Conglomerates of the Coal Measures, since these pebbles are all well rounded, while the softer fossiliferous and oölitic pebbles of chert are sub-angular. As has been pointed out before, the general characters of this group change on crossing the Alabama River, when the subjacent rocks are the Crystalline Schists. Here the pebbles are all quartzose, except in the lowest measures, when they are occasionally made up of water-worn bits of Crystalline rocks. In some sections of

* Bulletin No. 43, U. S. Geolog. Survey, p. 116, 1887.

the state, this Group has been found to be slightly auriferous, notably in Marion county, where, in the vicinity of Gold Mine, the gravel yields from $1.50 to $2.00 when carefully washed in pans.

Resume.

A careful study of the variations of the several formations herein described, will show that from the oldest to the most recent, the influence of the Missisippi river has been exerted, and that our rivers in Alabama are of comparatively recent origin. From the deposition of sediments in the early Cretaceous seas to the close of the Tertiary, we see emphasized the estuarian character still retained by the father of waters.

The general features of the Tuscaloosa group seem to remain constant from New Jersey, or even Massachusetts, to the vicinage of the Mississippi; but with the Eutaw, a difference is seen. This group, the sediments of which were evidently deposited in ever shifting, perhaps very cold waters, inimical to molluscan life, is practically unfossiliferous west of the Alabama river. From the Alabama river eastward, there seems to have been a changed condition, for gradually fossil remains appear first in the form of casts in the vicinity of Prattville, and on the Chattahoochee there is an abundant fauna from the beginning to the close of the period.

The apparent absence of the Rotten Limestone group and the relative thickening of the Ripley beds, has been treated of fully already. It is to be hoped that some one after having studied the rocks in the field will carefully study the extensive Cretaceous fauna of this region as the ultimate grouping of this formation is still in the future, and to be rational must have some basis less arbitrary than mere lithologic differences.

It is in the Tertiary strata, however, that the variations are most perceptible. The thinning out and consequent disappearance of whole groups, and the interpolation of new beds have made this formation of unusual interest from a scien-

tific standpoint. These variations seem to have been caused by the existence of different conditions in the Tertiary sea or gulf. In northern Mississippi the Tertiary beds are exclusively lignitic in character, the fossils being leaf impressions, and lignitic beds and lignitic strata abound. Coming eastward into Alabama, the organic life becomes less fluviatile and more marine, numerous beds of tropical marine mollusca being found interstratified with beds of lignite and occasional leaf-bearing sands. This intermingling of well recognized invertebrate remains with leaf impressions in horizons whose age is beyond question, should afford a key that might solve the much discussed and still unsolved question of the interior Tertiaries. Careful search in the laminated sands and clays of these several Tertiary groups in Alabama should reveal to the paleobotanist some forms already known to occur in either the Laramie, Puerco, or Fort Union beds. After crossing the Alabama river, the Tertiary seems to lose nearly all of the lignitic facies and to become gradually more marine, so that on the Chattahoochee no lignitic beds occur, and the major part of the sediments are markedly calcareous.

General Section Exposed on the Chattahoochee River, Plate XXIX.

The successive beds exposed on the Chattahoochee from Columbus, Georgia, to Alum bluff are as shown in the following table, in which the order of enumeration is that of historical succesion, or the inverse of the stratigraphic succession. They are illustrated graphically, in connection with the Alabama and Tombigbee exposures, in the plate.

1. Light green, highly micaceous sand, resembling weathered schist; but for occasional water-worn quartz pebbles might be taken for schist ..... 3 feet.
2. Hard clay stained by ferruginous matter; breaks with conchoidal fracture ..... 1 foot.
3. Hard, white, coarse-grained sand, held together by white clay ..... 15 feet.

4. Red and gray variegated sandy clay (typical Tuscaloosa); shown at water's edge, mouth of Bull creek, Georgia.....6 feet.
5. Strongly cross-bedded coarse sand and pebbles with some few fragments of schist and just enough white clay to hold the mass together. The quartzose pebbles are all well water-worn, while the softer bits of schist are but slightly abraded. The stratum varies in color from white to lemon yellow and in places green, while the upper part becomes mottled purple and yellow. This last phase is most strongly developed at Thomas' bluff, Georgia, due east of Fort Mitchell, Alabama. Top of the Tuscaloosa.....40 feet.
6. Dark-gray calcareous sand, pyritous and containing nodular masses 6 to 12 inches in diameter with calcite nuclei. These nodules are arranged in strata about two feet apart and terminate in an indurated stratum about 12 inches thick. Small fragments of lignite are scattered about through this stratum, and one or two large masses filled with calcified teredos were found. The only other fossils seen were an *Anomia* and an *Exogyra*, probably the young of *E. costata*, Say. The fossils are all poorly preserved. Dip at this point, 40 feet to the mile southward.....15 feet.
7. Gray sands of the same nature as the preceding, only no nodules were seen, and the shells increase in quantity, particularly in the lower part. The upper part of the stratum becomes argillaceous and contains many fossil casts, mainly lamellibranchs; causes landslides in the banks like the Black Bluff clays, which they resemble somewhat physically. These sandy clays give rise to Uchee shoals.....100 feet
8. Laminated dark gray clays, with masses of yellow sand distributed at irregular intervals throughout the stratum; best developed just above Uchee creek, Alabama.....25 feet.
9. Yellow and white sands, with thin seams of lignitic sand and an occasional "bunch" of gray laminated clay. These sands are exposed in a bluff about 100 yards from the river, just south of Rooney's Mill creek, Georgia.....50 feet.
10. Quartzose conglomerate much like that at Havana, Hale county, Alabama; forms the shoal at Beden's rock and the bluff at Hatcher's lower landing; merges gradually into a yellow sand.50 feet.
11. Yellow sand and gray clay, containing bits of leaves. This stratum and the following are seen at Chimney bluff, Georgia.....60 feet.
12. Light-yellow and white sands, containing beds of well-rounded quartzose pebbles, sometimes 20 feet thick. Lignitized logs can be seen protruding from the bluffs. The sands contain a small *Exogyra* at rare intervals. The supposed top of the Eutaw group.....45 feet.

13. Gray, sandy calcareous clay, with lines of bowlder-like concretions projecting from the bank; first seen at Lawson's wood yard, Georgia. Few fossils occur in the lower part of this stratum, *Exogyra costata*, Say, a mile above Blufftown, Georgia, where characteristic Ripley shells, mainly bivalves, are found in a much decomposed state throughout a stratum 6 to 8 feet thick. The uppermost 10 feet of the stratum is very fossiliferous. The river washes out little cave like recesses in the banks. Near Jernigan's landing, Alabama, slight rolls in the strata are seen, involving about 20 feet of the sands, and these miniature anticlinals and synclinals continue to within two miles of Florence, Georgia. The dip, estimated from the line of bowlders, averages about 20 feet to the mile and is normal in direction.....120 feet.
14. Two miles above Florence, Georgia, and making part of a bluff 50 feet high at that place, there is a gray sand interlaminated with thin seams of a more argillaceous sand, all of which is unfossiliferous. Dip here about 40 feet to the mile.....26 feet.
15. Gray calcareous sands, containing a small, fragile *Anomia* and a line of hard, round concretionary bowlders.....40 feet.
16. Gray and yellow sands, resembling in physical character those of the Tertiary at Lower Peach Tree, Alabama .....30 feet.
17. Gray, highly fossiliferous marl. The fossils are nearly, if not quite, all bivalves, and are mostly comminuted as if they formed an ancient shore-line. There are numerous shark teeth and a hard black substance resembling in sections the under shell of a turtle, black coprolitic(?) pebbles, and fragments of lignite.3 feet.
18. Sandy stratum, indurated and containing *Ostrea*, sp. .....1 foot.
19. Cross-bedded gray sands and clay.....15 feet.
20. Fossiliferous marl, about the same in general character as 17, only little or no lignite was seen, the marl appearing to be somewhat glauconitic. (The strata from 17 to 21, inclusive, form a bluff on the eastern bank five miles below Florence, Georgia.....2 feet.
21. Gray, glauconitic, and calcareous sand, weathering into fucoidal masses and containing a few soft white phosphatic nodules.10 feet.
22. Gray fossiliferous marl, shells much decomposed. An occasional lignitized log and numerous slightly phosphatic nodular masses containing fossils occur in this stratum..... 5 feet.
23. About the same in general character as 21, but contains indurated ledges about a foot thick, which show the dip to average 40 feet to the mile, with numerous rolls; ends just above the mouth of Cowikee creek, Alabama..... 170 feet.
24. Soft, less coherent sand, gray in color; appears at the mouth of Cowikee creek, Alabama, from which the southern bank of the creek, composed of this stratum, may be seen to rise 50 feet from the water.....60 feet.

26. Gray calcareous sand, with indurated ledges, containing *Exogyra costata* Say; *Gryphæa vesicularis* Lam.; *Hamulus onyx*, *Plicatula urticosa*, *Anomia*, sp.; forms the shoal at Frances bar and bluff at Eufaula, Alabama.....180 feet.
26. Light-gray and yellow sands, interlaminated with sand darker in color, more argillaceous, and containing bits of lignitized leaves and twigs; no other fossils seen; crops out in the gullies of Eufaula next below the Orange sand.....20 feet.
27. Massive gray sand, with a few fragile fossils and bowlders. This sand is only slightly calcareous, and is more or less lignitic; dip here about 100 feet to the mile.....40 feet.
28. A more calcareous sand, filled with *Exogyra costata*, Say, and many indurated ledges, giving rise to the first bar below Eufaula .....70 feet.
29. Light-yellow cross-bedded sands enclosed between indurated ledges.....20 feet.
30. Calcareous gray sands, with bowlders.....50 feet.
31. Yellow sands and indurated ledges filled with casts, *Exogyra costata*, Say, and echinoids set fast in the ledges. The sands are cross-bedded and contain some lignitic streaks.....35 feet.
32. Gray fossiliferous sand, with bowlders. The sand is massive, and is fossil-bearing only in the lowest 5 feet.....40 feet.
33. Brown laminated argillaceous sand; disappears at the mouth of Pataula creek, Georgia.....5 feet.
34. Light-yellow sand, interstratified very irregularly with a gray micaceous sand filled with friable Ripley fossils; mouth of Pataula creek, Georgia.....30 feet.
35. Hard sandy ledge; weathered surface jagged; contains *Exogyra costata*, Say, and echinoids; very light yellow in color, white when dry and not weathered.....30 feet.
36. Gray sand, with indurated ledges; no fossils seen; merges gradually in the upper part into a dark, almost black, sand containing large nodular masses and interstratified with light-yellow sands.....35 feet.
37. White coarse conglomerate, the matrix material being calcareous. The quartzose pebbles decrease in size toward the top, and the stratum becomes more argillaceous. There are many casts, but all too obscure for identification.....18 feet.
38. Massive blue clay; contains a few bits of teredo-eaten lignite (probably top of Cretaceous).....6 feet.
39. Massive sandstone; coarse-grained and almost a conglomerate... .....8 feet.
40. Light-yellow silicious sandstone, containing a large *Ostrea* and numerous obscure casts; five miles above Fort Gaines, Ga.10 feet.
41. White calcareous sand, containing a few obscure casts and an *Ostrea*. The sand sometimes becomes irregularly indurated, and

is the source of numbers of small lime springs; forms the lowest part of the bluff at Fort Gaines, Georgia, and in its uppermost 10 feet contains pockets of white sand, enclosed by black clay, the clay resting in "potholes" in the limestone; estimated at 200 feet.

42. Glauconitic sand filled with *Grypthœa thisæ*, Gabb.; *Venericardia planicosta*, and *Crassatella tumidula*.....8–12 feet.
43. Gray, calcareous sandy clay, containing bowlders of clay and a few decomposed shells of *Gryphæa thirsæ*.....15 feet.
44. White and lignitic cross-bedded sands, and sandy gray clay containing one or two ledges of "pseudo-buhrstone".....50 feet.
45. Dark gray argillaceous sand, with few fossils and fragments of water-worn clay balls. The lower part becomes more fossiliferous, containing *Osteodes caulifera*, *Venericardi planicosta* and *Gryhhæa thirsæ*, etc.....6 feet.
46. Greenish-gray, fine-grained calcareous sand; very firm, and holding decomposed shells, mainly bivalves.....6 feet.
47. Coarse glauconitic sands filled with very large shells of *Ostrea compressirostra*, *Venericardia planicosta*, and a small pecten resembling the species occurring at Yellow bluff, on the Ala, 3 feet.
48. Cross-bedded yellow sands, the bedding planes being marked by streaks of gray clay.....10 feet.
49. Yellow and gray sandy clays, containing occasional beds of *Ostrea compressirostra* and *Gryphœa thirsœ*. The indurated ledges (seldom over two feet thick) which sometimes occur are of the nature of "pseudo-buhrstone," and are filled with bivalves, the only exception noted being *Turritella mortoni* (large). This member disappears below the surface at the mouth of the first large creek flowing from the Georgia side below Fort Gaines...75 feet.
50. Light yellow and gray sandy clays, containing in the sandier portion bowlders much like those seen at Bell's landing; no fossils seen. These are undoubtedly the Lower Peach Tree clays and sands. They become more sandy on ascending.....170 feet.
51. Light greenish yellow sand filled with bits of decomposed shells and large specimens of *Ostrea compressirostra* and *Venericardia planicosta*. (Interval of 50 yards).....3 feet.
52. Gray sand filled with decomposed fossils. An irregular indurated ledge (non-fossiliferous) occurs in this stratum. This is probably Bashi, though the only fossil that could be determined with any degree of accuracy is the small oyster so common at the typical locality.....18 feet.
53. Blue, slightly sandy clay.....6 feet.
54. Light yellow, silicious (sandy) limestone filled with casts and containing pockets filled with shells of *Ostrea compressirostra*.....18 feet.
55. Gray lignitic sandy clay (Hatchetigbee).....10 feet.

56. Coarse white sand, containing *Ostrea diraricata* and a few other friable shells in the upper part. (The first flexures since leaving Eufaula occur in this strata.) ..... 12 feet.
57. Plain buhrstone, rather sandy ..... 40 feet.
58. Light, yellowish green sand containing numbers of small shells of *Ostrea sellæformis* ..... 45 feet.
59. Buhrstone ..... 55 feet.
60. Greenish-yellow calcareous clay, with a few decomposed fossils and an occasional large shell of *Ostrea sellæformis* ..... 12 feet.
61. White sandy limestone, with small shells of *Ostrea sellæformis* in abundance and pockets of larger sized shells. Makes capping ledge to island at mouth of Omussee creek, where the bluff is about twenty feet high. This stratum is made up of alternate beds of hard and soft strata, all containing more or less abundant remains of *Ostrea sellæformis*. The harder strata weather out into root-like shapes, and are sometimes rather argillaceous. Many return dips occur in this stratum, stringing it along the banks for many miles further than it would extend normally. The dips are all steep both ways, and many gaps in the succession are caused by the washing out of their softer strata. Owing to these gaps and return dips, it is rather difficult to estimate the thickness of this stratum with much accuracy. It dips below the surface of the river two miles below Gordon, Alabama, and is last seen on the Georgia bank. At Gordon there is a very pronounced return dip. Estimated at (and not exceeding) ..... 60 feet.
62. The "*Scutella* bed:" weathers so as to make it impossible to "count up" its thickness. It is literally full of fossils, mainly *Scutella lyelli* (?) and *Pecten nuperus*, with a few smaller and thicker shells of *Scutella*. A bluff about 20 feet high occurs opposite the mouth of Cowhatchee creek, Georgia ..... 25–30 feet.
63. White orbitoidal limestone, seen first at Dougherty's wood-yard (Georgia), on the Alabama bank, 9 miles by river from Neal's landing, Alabama. The limestone contains numbers of echinoids about five miles above Neal's. The limestone continues as far as Miriam's landing, at which place the thickness is ..... 200 feet.
64. Argillaceous and sandy limestone, alternating with strata of purer character. Contains a pecten and an *Ostrea* very close to our recent *virginica*. This may be termed the Chattahoochee limestone. It is well developed there and in the eastern river bank for the succeeding 10 miles ..... 25 feet.
65. Light yellow sand, containing pockets of fossils. Where there are no shells the sand is very calcareous. Fossils resemble those described by Conrad as Miocene from York county, Virginia, and Maryland ..... 35 feet.
66. Gray sand, slightly calcareous ..... 5 feet.

67. Gray calcareous sand filled with shells. The leading fossil is a *Mactra*..... 10-15 feet.
68. Black lignitic sand. This contains much pyrite, and from the efflorescence of ferrous sulphate arises the name Alum bluff; varies with preceding..... 10-15 feet.

PART II.

THE PHOSPHATES AND MARLS OF THE STATE.

—BY—

Eugene A. Smith.

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THE PHOSPHATES AND MARLS OF ALABAMA.

HISTORICAL.

In the early part of the spring of 1844 I received from Mr. J. W. Spencer, of Hamburg, Perry county, a box of phosphatic nodules and shell casts. Mr. Spencer's attention had been directed to these things which occurred on his land, by some published description of the South Carolina phosphates. He had sent specimens to Dr. C. U. Shepard, of Charleston, S. C., who had analyzed them, and, on recognizing them as phosphates, had sent his assistant, Dr. Chazal, to Alabama to investigate the occurrence. Dr. Chazal examined the ground and came to the conclusion that the phosphates were not in sufficient quantity to be of commercial value, and his conclusion seems to be borne out by our subsequent investigations, so far as the *high grade* phosphates are concerned, and these were all that Dr. Chazal particularly examined.

In April, 1884, I went to Hamburg personally to see the mode of occurrence of the phosphates, and finding in addition to the nodular phosphates, a phosphatic greensand, and being satisfied that the latter, at least, would become an article of great value to our agricultural interests, I announced the fact through the papers, and sent Mr. D. W. Langdon, Jr., Assistant in the State Geological Survey, to examine the occurrences about Hamburg more closely, and to follow the outcrop of these deposits from Hamburg east and west across the state.

Soon after my announcement, Prof. Stubbs, of Auburn, and his Assistant, Prof. Leroy Broun, Jr., came also to Hamburg and the last named gentleman was with Mr. Langdon in his subsequent investigations about Hamburg.

Afterwards, Mr. Broun went into Macon, Russell, and Barbour counties, where he also found the phosphates.

Mr. Langdon traced the Hamburg deposits across to Eutaw, and eastward to near Selma. I sent Mr. John Daniel of this University down to Summerfield, and afterwards to east Dallas and western Autauga, and later still, into the southern part of Dallas county, where he collected for the survey some valuable notes of the occurrence in those localities.

Having indicated in the newspapers, several places at which I thought the phosphates likely to be found, I received, from persons all along this line of probable outcrop, specimens which in most cases proved to be phosphatic.

Thus in a very short time, it was known that the Hamburg belt of phosphates extended from the Mississippi line through Pickens, Greene, Hale, Dallas, Autauga, and Elmore counties, while Prof. Broun's examinations showed them to exist in Macon and Russell.

A systematic examination of the specimens in the collection of the Geological Survey in the cabinet of the University, soon revealed the fact that the limestones and other rocks of the Ripley group of the Cretaceous formation, immediately *overlying* the Rotten Limestone, were in places more or less phosphatic. This was announced in the newspapers, and a list published of the localities where the phosphates were likely to occur, and in a short time specimens were sent up to the University from many localities showing that the phosphates were very generally present along this belt also across the entire state. Examinations were made by Mr. John Daniel, Mr. Langdon and myself of these deposits in Dallas, Wilcox, Marengo, and Sumter coun-

ties as to their mode of occurrence and the thickness of the beds.

During the summer of 1884 Mr. Langdon, while collecting for Mr. T. H. Aldrich in the southern part of the state, discovered that there were phosphatic materials occurring still further south in the Tertiary formation, the previously discovered beds being in the Cretaceous.

In the spring and early summer 1884, many analyses of phosphates were made at the University of Alabama, and later in the summer I sent the specimens collected by me, either through my assistants or through correspondents, over to Auburn where they were analyzed in the state laboratory of the A. & M. College under the supervision of Prof. Stubbs. The results of these analyses were published in Bulletin No. 5, of the Agricultural Department, with a joint report on the phosphates of Alabama, by Prof. Stubbs and myself.

The specimens analyzed were all contributed by the Geological Survey, except about twenty, which were furnished by Prof. Broun from the eastern counties of the state. The specimens from Hamburg analyzed at the state laboratory were collected by Messrs. Broun and Langdon. The arrangement of the material in this Bulletin No. 5 is such that it is very difficult to make any practical use of the analyses, and a reprint of the same will not be amiss.

Soon after the announcement of the discovery of the phosphates, hopes of making sudden fortunes were raised in the minds of many of our citizens, but when, after further investigation, it seemed improbable that high grade phosphates suitable for exportation would be found in Alabama in commercial quantity, there came a reaction, and doubts have arisen as to whether our phosphates are worth anything at all. With the example of New Jersey before us, there should be no possibility of a doubt as to the future of agriculture in Alabama.

If we compare the two states, New Jersey and South Carolina, one of which has only low grade phosphates suitable for use at home but not rich enough for export, the other with high grade phosphates which are shipped to all parts of the world, we can hardly fail to see that the advantage to the state at large is in favor of New Jersey with its low grade marls. In South Carolina the phosphates are either exported or manufactured into high grade fertilizers from which, in all probability, the soils of that state derive no more benefit than the soils of other states.* The marls of New Jersey, on the other hand, are used almost exclusively upon the soils of that state, and the result of twenty-five years application of them has been to cause the lands of New Jersey to be worth more per acre than those of any other state.

With an abundance of high grade phosphate only, in this state, it is probable that our experience would not be different from that of the people of South Carolina; our soils would as a rule be no better for it, since the greater part would undoubtedly be exported to enrich the soils of some other country.

On the whole it seems to me to be a matter for congratulation rather than otherwise that the most abundant phosphates of Alabama are of a nature which will probably keep them at home. If they are used rationally by our people, there can be no doubt that the enhancement in the value of lands and the increase in the crops due to their use, will represent a larger amount of capital than would the trade in exported rock. And even if the sums realized by exportation were greater the money would be in fewer hands, and therefore would accomplish less general good.

It is discouraging that our people as a rule are so slow in taking advantnge of the natural fertilizers of the state.

* The same may be said of Florida, whose high grade phosphates are now shipped to all parts of the world.

This is, however, in great measure due to lack of information on the subject; and as comparatively little printed matter comes under the notice of the majority of our farmers they can never be induced by any amount of writing to take up these things which lie at their very door.

It is only by the example of the best posted, and most successful farmers of each neighborhood, who are willing to experiment with these fertilizers, and show practically their value, that the great mass of the farmers will ever be brought to use them. Fortunately, in several parts of the state, there are farmers who have made practical field tests of these marls, and from these as a center, the infection will spread it it to be hoped, over the whole state.

GEOLOGICAL AGE, MODE OF OCCURRENCE, AND COMPOSITION OF THE PHOSPHATES.

Phosphatic marls have been found in Alabama both in the Cretaceous and Tertiary formations, and for our present purposes they can be most conveniently considered in their geological relations.

From the margin of the area occupied by the rocks of the older formations of this state, the strata of the Cretaceous and Tertiary formations, make up the whole mass of the land southward to the Gulf of Mexico. The margin of these older rocks, which is at the same time the inner or upper margin of the lowest of the Cretaceous formations, stretches in a curve from the northwestern corner of the state across near Fayette Court House, Tuscaloosa, Centerville, and Wetumpka, to Columbus, Georgia. All the Cretaceous and Tertiary beds have a gentle slope or dip towards the Gulf of 25 to 40 feet to the mile, and they occupy the surface across the state in approximately parallel belts, the oldest beds furthest north, and the newer further towards the south in the order of their relative ages. As a further consequence of this dip of the strata, each one of these beds, while appearing at the surface only in a comparatively nar-

row belt, passes beneath the newer beds, and may be found below the surface at depths constantly increasing as we go southward.

The geographical distribution of the surface outcrops of the several divisions of the Cretaceous and Tertiary may be seen by reference to the map accompanying my Agricultural Report for the years 1881-2*. But since that report will probably be accessible to very few, I shall preface the detailed descriptions of the marls, by a short account of each of the formations in which they occur:

CRETACEOUS FORMATION.

General Characters.

This formation is made up of some 2,600 to 3,500 feet in thickness of strata, which are sands, clays, and limestones in many alternations. The subdivisions of the formation are four in number, which in ascending order are as follows:

1. THE TUSCALOOSA.—This, the lowermost of the Cretaceous series, consists in the main of sands and clays aggregating, by estimate, 1,000 feet in thickness. The sands are usually light colored and cross-bedded; the clays are in part laminated in which case they often hold well preserved leaves and other remains of plants and occasionally small beds of lignite; and in part massive when they are of dark red and purple colors on the outcrop, where exposed to the air, but usually of dark gray color where fresh and protected from the action of the weather. The clays of this formation are quite similar both in composition and in their geological relations, to the clays of New Jersey, and are gradually being utilized in this state in the manufacture of fire-brick, pottery, etc. All the materials and the fossils of the Tuscaloosa formation, and the numerous beds of pebbles, as well as the cross-bedded sands, testify to the existence of currents when the beds were deposited.

*It is probable that a geological map of the State will be ready for distribution, by the time this Report is printed.

2. THE EUTAW.—Next above the strata of the Tuscaloosa come those of the Eutaw, which, like the former, are in the main composed of sands and clays, but which, unlike the Tuscaloosa beds, often hold grains of the mineral known as *greensand or glauconite*, essentially a compound of silica, iron and potassium, and of marine origin. The greensand beds, upon exposure to the air, gradually assume a yellowish brown or reddish color due to the oxidation of the iron of the greensand.

The Eutaw beds in places hold also marine shells, usually much decomposed and difficult of identification, but still proof of their marine origin. Other beds of the Eutaw series on the contrary are filled with leaf impressions and other fossils of vegetable origin, in which they resemble the underlying Tuscaloosa beds. The thickness of the Eutaw may be put at about 300 feet.

3. THE ROTTEN LIMESTONE OR CHALK.—Overlying the Eutaw there is a great thickness, up to 1,000 feet, of calcareous strata, prevalently a clayey limestone or indurated marl, but with admixtures of clay beds and of beds of true chalk (a soft friable limestone consisting almost entirely of microscopic shells, similar to those which are at present found only in the deep parts of the sea). At the base of this calcareous formation, as well as at its summit, there are transition beds more or less sandy, grading on the one hand into the Eutaw beds below, and on the other hand into the Ripley beds above. It is in these transition beds that the phosphates occur, and to them we shall accordingly direct special attention in the sequel. While the Tuscaloosa and Eutaw divisions continue across the state with tolerably constant characters, the chalk thins out to the eastward and has not been identified eastward of Macon and Bullock Counties.

4. THE RIPLEY.—Next above the Rotten Limestone, and forming the uppermost member of the Cretaceous formation, lie the beds of the Ripley series, so named from their characteristic occurrence near the town of Ripley in Mississippi. These consist of hard sandy crystalline limestones

near the base of the series and calcareous clays and bluish micaceous, sandy marls above. The alternation of harder and softer beds gives character to the topography of the country in which these rocks occur, and which in western Alabama is known as the "hill prairie" country.

The prairie hills are usually very steep and abrupt, and the depression between them are filled in with the sandy loams of the LaFayette* formation, usually more or less mingled with the washings of the calcareous clays which alternate with the hard limestone ledges of the hillsides. The soils resulting from these mixtures are stiff, marly and in many cases extremely fertile. Towards the eastern part of the state the bluish, sandy, micaceous marls become more prevalent and attain a very great thickness, and occupy the surface over a belt nearly 100 miles in width. The well known farming lands of the Cowikee Creek and Bear Creek in Russell and Barbour counties are based upon these blue marls. The thickness of the Ripley varies between wide limits, being perhaps 500 feet as a maximum in west Alabama, and increasing to much more than 1,000 feet in east Alabama, where the Rotten Limestone seems to be entirely wanting.

Phosphatic Deposits of the Cretaceous.

As before stated, the phosphatic deposits of our Cretaceous formations occur mainly in two positions, viz: At the base and at the summit of the Rotten Limestone; in both cases in transition beds between this and the underlying and overlying rocks. The Rotten Limestone being, as above noted, a calcareous clayey formation in great part, yields upon disintegration soils that are for the most part strongly limy, and colored dark and sometimes nearly black with

*This is the name given to that mantle of red loam and pebbles which overspreads the greater part of the southern half of Alabama, in many cases hiding more or less completely the older rocks of the country. This formation has heretofore been described under the name of "Drift" and "Orange Sand."

vegetable matter. The region formed by the Rotten Limestone is commonly known throughout this state under the names "Black Belt," "Canebrake," "Black prairies," in allusion to prominent characteristics. The positions of the two areas in which the most important of the phosphatic deposits are to be looked for as easily located; the one occurs along the northern border of the prairie belt, and the other along its southern border, in both cases where the transition from the lime lands to the sandy lands is found. The phosphate belt to the north of the prairies we have named the *Eutaw, Hamburg, Selma Belt;* the one to the south of the prairies is known as *Livingston, Fort Deposit, Union Springs Belt.* In the special descriptions of these occurrences it will be best to consider them separately.

1. The Eutaw, Hamburg, Selma Belt.

HAMBURG.

Mr. J. W. Spencer appears to have been the first to suspect the character of the phosphatic nodules which are so abundant about the old town of Hamburg, in Perry county. After analyses made by Dr. C. U. Shepard, of Charleston, S. C., and in the Laboratory of the Alabama Geological Survey at Tuscaloosa, had placed beyond doubt the composition of these nodules, the locality was visited and closely examined by a number of persons, but particularly by Mr. D. W. Langdon, Jr., of the Geological Survey, and Mr. W. Leroy Broun, Jr., Assistant Chemist of the A. & M. College.

The following section of the strata at Hamburg, given in descending order, will show the mode of occurrence and general character of the phosphatic materials at that place:

Sections at Hamburg.

1. Base of the Rotten Limestone. The beds here included contain very little phosphoric acid.

2. Greensand, averaging about five feet in thickness, and strongly impregnated with phosphoric acid. The lowermost strata of this greensand contain a few phosphatic nodules, which, however, become much more abundant in the next succeeding stratum.

3. Sandy calcareous stratum, matrix of the nodules, five to six feet in thickness. Where this bed outcrops in the fields the surface of the ground is covered with the phosphatic nodules, which are concretionary masses of nearly pure phosphate of lime, of exceedingly irregular shapes, and sizes varying from small pebbles no larger than a pea to pieces two or more inches in diameter. The nodules vary also in color, from light gray to dark brown, and they may easily be recognized by the peculiar odor which they emit when rubbed together or broken. This odor is described by some as "fishy," by others as "bituminous" or "naphthous," it resembles to some degree the odor of crude petroleum. Along with these phosphatic nodules are also great numbers of casts or moulds of fossils, usually somewhat worn, and badly preserved, and consisting of fragments of ammonites, baculites, nautili, and other well known Cretaceous forms. These casts have themselves, in most cases, been more or less phosphatized, and in some instances have almost entirely lost their original shape and structure, and are then difficult to distinguish from the nodules. Besides these there are great numbers of the teeth of sharks and bones of saurians.

The nodules are found as above stated, in small numbers in the lower beds of greensand, but more abundantly in the next underlying stratum, mainly through about two to two and a half feet of its thickness. In quantity, according to the estimates of Messrs. Langdon and Broun, these nodules would average some two to eight hundred tons to the acre. The nodules compare favorable in composition with those of South Carolina, as may be seen from the analyses given below.

4. Hard ledge of calcareous sand, six to eight inches in thickness, and holding a considerable quantity of phosphoric acid as shown by the subjoined analyses.

5. Loose sandy beds, micaceous, with numbers of sharks' teeth and in the upper part just beneath the hard ledge No. 4, filled with the shells of small oysters. The division is about thirty feet thick, and holds some phosphoric acid as may be seen from the analyses.

6. Compact laminated sands consisting of white quartz grains mixed with grains of greensand, 15 feet.

7. Compact blue sands with greensand, 8 to 10 feet.

Beds Nos. 6 and 7, as well as part of No. 5, are well exhibited in a bluff just below Mr. Spencer's house, and east of the road.

The following pages will show the composition (or rather the contents of phosphoric acid) of the various materials occurring at Hamburg:

a. The Nodules and phosphatic Casts of Fossils from Spencer's Field, Hamburg.—The nodules and phosphatic casts which cover the ground in some parts of Mr. Spencer's field, have evidently come from the disintegration of bed No. 3 above, and represent the accumulation of years. In order to ascertain the proportion of these phosphates in the original rock, Mr. Langdon, at my suggestion, had four pits dug into No. 3 at different places, and collected and weighed the nodules occurring in a measured quantity of the earth from different depths in these pits, and from this he estimated the amount per acre of the phosphates which this bed would yield. His average of several such estimates is 377.92 tons to the acre, the nodules being distributed through 4 to 6 feet thickness of the matrix rock. It is doubtful if it would pay to extract these from the rock, but where they have already been weathered out and lie upon the surface, there would be no trouble in raking them up, and the amount which could thus be gathered is very considerable.

The Table on p. 460 will show the composition of the higher grade materials from Spencer's Field.

Analyses of Phosphatic Nodules and Shell Casts, Spencer's Field, Hambury.

	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
1. Surface Nodules (selected)	.....	38.00	82.84	.....	John Daniel, Univ'ty of Ala.
2. " "	.....	35.5	77.39	.....	" "
3. Surface nodules, sample of 1 lb	.....	25.66	55.88	.....	Chas. Gibson, Chicago.
4. Nodule	.....	22.02	48.00	.....	W. I. Hersberg, Univ. of Ala.
5. Phosphatized shell	.....	19.80	43.16	.....	" " "
6. Surface nodules	1.09	26.18	57.04	.....	Laboratory A. & M. College.
7. Black nodules	2.50	24.16	52.62	.....	" " "
8. White nodules	21.94	20.07	43.81	.....	" " "
9. Mixed nodules	9.79	19.97	43.59	.....	" " "
10. Nodules from Pit No. 1	22.07	14.02	30.60	39.02	" " "

b. Matrix of the Nodules, Spencer's Field, Hamburg.—It may be seen from the section (page 460) that the nodules are imbedded in a stratum some five or six feet thick. The material of this matrix is sandy and calcareous, and it is strongly phosphatic, as may be seen from the analyses following, (page 462). It would undoubtedly be a good fertilizer:

Analyses of the Matrix of the Nodules, Spencer's Field, Hamburg.

		Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
11.	Matrix of nodules	.....	4.2	9.16	.....	John Daniel, Univ'ty of Ala.
12.	Blue matrix of nodules	.....	2.2	4.80	.....	Chas. Gibson, Chicago, Ill.
13.	White matrix of nodules	.....	3.6	7.85	.....	" "
14.	Matrix rock, from Pit No. 1	30.28	2.58	5.63	30.06	Laboratory A. & M. College.
15.	" " " 3	32.50	3.85	8.40	29.64	" " "
16.	" " " 1	40.61	2.45	5.34	27.07	" " "
17.	Matrix rock, 6 feet below surface, Pit No. 3	53.74	2.79	6.09	17.20	" " "
18.	" 5 feet 9 in. below surface, Pit No. 1	33.81	2.26	4.93	27.85	" " "
19.	" 20 in. below surface, " 2	47.18	1.46	3.18	24.41	" " "
20.	" 9½ in. below surface, " 2	27.82	.95	2.09	41.00	" " "
21.	" 21 in. below surface, " 2	31.55	3.58	7.81	32.07	" " "
22.	Rock overlying matrix rock	35.17	2.20	4.80	24.10	" " "

c. *The Greensand, Spencer's Field, Hamburg.*—This bed is some five feet in thickness, and is throughout rather strongly impregnated with phosphoric acid. In some parts of the field, where exposed, this substance is indurated into a pretty firm rock, but in other places it is friable and incoherent, and occasionally it forms the surface soil which is cultivated. The analyses show a considerable variety in the percentage of phosphoric acid, the indurated rock containing the largest proportion, the loose rock next, and the soil least. Some of the analyses made from picked specimens of the hard greensand rock, show as much as 10 per cent phosphoric acid, but as the average is a good deal lower than this, I have inserted in the table (page 464) only such analyses as appear to represent the general average per cent of the phosphoric acid. The greensand taken from the pits dug by Mr. Langdon, show less phosphoric acid than the samples taken from the surface.

Analyses of Greensands—Spencer's Field, Hamburg, Perry County.

	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
23. Indurated, greensand	.....	9.00	19.62	.....	John Daniel, Univ'ty of Ala.
24. " "	.....	5.16	11.26	.....	C. R. Westcott, " "
25. " "	.....	8.12	17.70	.....	Eugene A. Smith " "
26. " "	.....	7.60	16.59	.....	Chas. Gibson, Chicago.
27. Greensand, first 12 in. Pit No. 1	42.66	1.61	8.51	16.18	Laboratory A. & M. College.
28. " 9 in. below 27 "	84.52	2.79	6.09	13.86	" " "
29. " 7 in. below 28 "	81.55	2.13	4.65	9.14	" " "
30. " 20 in. below 29 "	.....	3.88	7.37	8.40	" " "
31. Greensand forming soil, cultivated	41.42	.67	1.46	29.62	" " "
32. " " "	41.11	.85	1.85	17.68	" " "
33. " " "	48.81	4.35	9.56	9.13	" " "
34. " " "	28.62	.66	1.44	24.80	" " "
35. White nodules found in greensand	8.91	3.85	8.40	49.83	" " "
36. Indurated greensand	.....	4.80	10.26	.....	D. W. Langdon, Jr., U. of A.
37. " "	.....	5.90	12.86	.....	" "

In order to ascertain whether or not it would be possible to concentrate the phosphatic material or the greensand grains of this stratum, Mr. Langdon made some experiments with the indurated greensand, loosely pulverizing it, subjecting it to strong mechanical agitation, then separating the upper half from the lower, and analyzing each as to its content of phosphoric acid and potash. Another experiment was made by stirring the pulverized greensand in water, allowing it to settle and then determining the phosphoric acid and potash of the upper and lower halves as before. In neither case was any very marked result obtained, but there seems to be good reason for thinking that by some such mechanical process, it will be possible to concentrate the phosphate so as to render it suitable for shipment.

d. Sands and other strata underlying the nodule bearing bed at Spencer's, near Hamburg.—Samples were taken of the materials underlying the nodule bed, at intervals of three feet, for some eighteen to twenty feet, and also of the indurated ledge between the nodule bed and the sands. All these contain phosphoric acid in considerably larger proportions than is commonly found in soils.

The subjoined analyses (page 466) show the phosphoric acid in the different parts of the Hamburg strata:

Analyses of the Strata Underlying the Nodule Bed—Spencer's, Hamburg.

	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
39. First three feet below surface, Spencer's house	31.53	3.38	7.37	26.73	Laboratory A. & M. College.
40. Three feet below 39	56.65	.69	1.50	21.20	" " "
41. Indurated ledge	53.77	1.16	2.53	23.33	" " "
42. Two feet below ledge No. 41	92.30	.33	.72	9.47	" " "
43. Sands 3 feet below 42	91.89	.29	.63	2.85	" " "
44. Sands 3 feet below 43	95.55	.44	.96	.72	" " "
45. Sands 3 feet below 44	96.27	.12	.25	.75	" " "
46. Sands 3 feet below 45	92.14	.39	.85	.69	" " "
47. Feruginous sand below King's Mill	91.40	.43	.92	.79	" " "
48. Lowest formation at King's Mill	90.42	.25	.54	.50	" " "

No. 39 is evidently a part of the nodule bearing stratum of which several analyses have been given in a preceding table (page 462).

NEAR CAHABA RIVER.

From Hamburg, Messrs. Langdon and Broun followed the phosphatic formation eastward to the Cahaba River, where the following geological section was observed by them:

Section near Cahaba River, on land of Messrs. A. F. and A. J. Davis.

1. Rotten Limestone, increasing in depth southward.
2. Greensand marl, 5 to 6 feet thick.
3. Soft cream-colored rock, phosphatic, and bearing some nodules, and passing below into a grayish limestone holding the nodules, 4 to 6 feet.
4. Indurated calcareous sandy ledge, 1 to 1½ feet.
5. Yellow micaceous sand, the upper part holding shells; 30 feet.
6. Dark red sand containing more greensand than No. 5, the red color due probably to oxidation of greensand, 15 feet.
7. Indurated ledge similar to No. 4, but more variable in thickness, 6-12 inches.
8. Whitish sand with few grains of greensand, 10 inches.
9. Blue joint clay varying from 8 inches to 4 feet in thickness.
10. Red or orange colored sands similar to No. 6, 10 feet.
11. Greensand, four feet exposed above the water level in Cahaba River.

WEST OF HAMBURG.

Westward from Hamburg, Mr. Langdon traced the greensand and accompanying nodule bearing bed, by Marion, Newberne, Greensboro, Cocke's Mill, etc., to Eutaw, and from correspondents I have also received specimens from Pleasant Ridge and Pickensville. Subsequently, Judge Lawrence C. Johnson, of the U. S. Geological Survey, followed the line of outcrop of these beds far into Mississippi.

Between Hamburg and Cocke's Mill, six miles west of Greensboro, the greensand bed has substantially the same characters as at Hamburg, and the phosphatic nodules are also similar in quantity and quality to those already described. I have given below a number of analyses of the different kinds of phosphatic materials occurring along this line. There is no reason for thinking that the occurrence is not continuous between Hamburg and Cocke's Mill, or indeed to the Mississippi line. See analyses 49 to 60, (page 471).

On the Warrior River these deposits are again seen at Choctaw Bluff and at the old Erie landing. At both places the greensand is found immediately underlying the lowermost beds of the Rotten Limestone. At Erie, curious stalagmitic masses of indurated sand are formed in the loose sands which fall down the face of the bluff, the cementing principle being, as analysis shows, phosphate of lime. Analyses are found in the subjoined table Nos. 61 and 62, (page 471).

At Eutaw the greensand bed is well seen in the railroad cut near the depot. This greensand contains some imbedded phosphatic nodules, but the greater part of the nodules are to be found in a whitish sandy calcareous matrix, also seen in the railroad cut; at a well in the fair grounds; in a field east of town, belonging to Mr. Kirksey; and on the western

edge of town at Mr. C. S. Bray's. In all these localities there are phosphatic shell casts, sharks' teeth, and the other fossils common to the phosphate beds elsewhere. Analyses of the materials occurring about Eutaw are seen in the table (page 471), Nos. 63, 64, 65, 66 and 67.

Specimens have also been received from Pleasant Ridge, from Mr. R. K. Horton, from the Turkey Creek hills close to that town; and from Pickensville Mr. Walton Harrison has sent others. From both these localities, only nodules and phosphatic casts have come, but there seems to be no reason for thinking that the greensands are absent. For analyses see table (page 471) numbers 68 and 69.

EAST OF HAMBURG.

Mr. John Daniel, of the University of Alabama, went for me to examine the country east of Hamburg, and found the phosphates between Selma and Summerfield, and within a few miles of the first named place. From here he went into Autauga county, following the line of the outcrop of the phosphates as far as Prattville. Meanwhile I had received from several gentlemen near Selma specimens from a number of localities which proved to be phosphatic, and in Autauga county Mr. Leonidas Howard and Dr. S. P. Smith made tolerable thorough examinations of the vicinities of Mulberry and Prattville, where the greensand beds were discovered. The analyses of these greensands show that they are valuable fertilizers.

Along with the greensands are the usual phosphatic nodules and shell casts, and near Prattville also Col. Doster's farm and Dr. A. S. McKeithen's place, a hard phosphatic limestone, which may some day be utilized. From the vicinity of Wetumpka also came specimens from Mr. John Enslen showing that the greensand deposits extended in that direction also. Prof. Broun of Auburn has traced the outcrop of the phosphatic deposits through Macon and Rus-

sel counties almost to the Georgia line, but found them so deeply covered with the sands of the Lafayette that they will hardly be utilized.

We thus see that the phosphate outcrops across the state probably without a break in the continuity, and with very considerable uniformity in composition, and it is almost certain that valuable greensands are to be had merely for the cost of digging them up, for this whole distance,

The following tables (pages 472 and 473) show the composition of the materials which have been collected from the various localities east of Hamburg.

Analyses of Specimens Occurring Westward from Hamburg.

		Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
	MARION AND VICINITY.					
49.	Phosphatic casts, A. T. Moore	7.91	27.74	60.55	.....	Laboratory A. & M. College.
50.	Indurated Phosphate rock, M. W. Oliver	7.61	11.05	24.12	.....	" " "
51.	Light colored greensand, M. W Oliver	.....	2.98	6.50	.....	" " "
52.	Dark bluish greensand, M. W. Oliver	.....	2.57	5.61	.....	" " "
53.	Phosphatic nodules, Judge Bailey	25.91	26.74	58.37	33.55	" " "
54.	Greensand, Carlos Reese	37.70	3.78	8.25	.....	" " "
55.	Phosphatic casts Dr. W W Wilkerson	12.55	14.23	31.06	.....	" " "
	NEWBERNE AND GREENSBORO AND VICINITY.					
56.	Greensand, E. N. Driver, Scott's Station	.....	2.36	5.15	.....	" " "
57.	Nodules and phosphatic casts, Mrs. Jemison	10 85	23.10	50.43	.....	" " "
58.	Phosphatic casts, Charles W. Turpin	7.73	26.54	57.94	.....	" " "
59.	Phosphatic casts, Dr. J. B. Reid, Greensboro	16 22	23 20	50.64	39.34	" " "
60.	Greensand, Cocke's Mill	.....	4.30	9.38	.....	Charles Gibson, Chicago.
	WARRIOR RIVER.					
61.	Greensand, Choctaw Bluff	.....	5.03	10.96	.....	W. I. Herzberg, Univ of Ala.
62.	Stalagmitic formation, Erie	.....	1.16	2.53	.....	D. W. Langdon, Jr., Univ. Ala.
	EUTAW AND VICINITY.					
63.	Greensand, from railroad cut, Eutaw	.....	.60	1.31	.....	Laboratory A. & M. College.
64.	Indurated greensand, Fair Grounds, Eutaw	39.87	3.24	7.07	.....	" " "
65.	Nodules and casts, Kirksey's field	9.44	21.53	47.00	.....	" " "
66.	Greensand marl, T. J. Anderson, Eutaw	.....	1.53	3.35	.....	Eugene A. Smith.
67.	Phosphatic nodules, A. W. Anderson, Eutaw	26.99	16.48	35.97	34.57	Laboratory A. & M. College.
	WEST OF EUTAW.					
68.	Nodules and phosphatic casts, Pleasant Ridge	5.90	25.14	54.88	.....	" " "
69.	Nodules and phosphatic casts, Pickensville	4.21	22.40	18.90	.....	" " "

1. *Selma, Summerfield and Vicinity.*

	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
70. Nodules, from near Selma	.....	26.1	56.90	.....	John Daniel, Univ'ty of Ala.
71. " " "	.....	25.8	56.24	.....	" "
72. " " "	.....	36.0	78.68	.....	" "
73. " " "	.....	38.0	82 84	.....	" "
74. Matrix of nodules, from near Selma	.....	5.05	10 11	.....	" "
75. " " " "	.....	3.98	8.67	.....	" "
76. Greensand, three feet thick, J. R. Barker's Mill	.....	3.60	7.85	9.70	Laboratory A. & M. College.
77. Greensand, J. R. Barker's Mill	.....	5.17	11.26	.....	John Daniel.
78. Nodules, 3 m. S. E. of Summerfield, overlying greensand	3.67	25.59	55.85	....	A. & M. College Laboratory.
79. Greensand, near Selma, Jos. Hardie	.....	5.22	11.39	.....	" "
80. Nodules and casts, near Selma, J. H. Robbins	6.49	24 85	54.25	31.57	" "
81. Nodules and casts, near Selma, Keenan place	50 68	12 88	28.11	22.20	" "

2. *Autauga and Elmore Counties.*

Analyses 82 to 89 inclusive are from specimens collected in western Autauga by Mr. Leonidas Howard; 90 and 91 are from Day's Bend, sent by Mr. W. A. Gunter; 92 to 96 inclusive, from near Prattville, sent by Dr. S. P. Smith and John Daniel; and 97, 98 and 99, collected by Mr. John Enslen, of Wetumpka.

	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
82. Hard Silicious limestone, near Mulberry	57.17	0.78	1.70	.....	Laboratory A. & M College
83. " " " with shell casts, near Mulberry	49.05	4.86	10 61	26.55	" " "
84. Clayey limestone, with green sand upper part, "	.....	2.20	4.80	7.99	" " "
85. Clayey limestone, with greensand lower part, "	.....	1 69	3.69	14.89	" " "
86. Greensand ten inches thick, Mulberry	.....	2.49	5.43	8.38	" " "
87. Greensand marl from well, Mulberry	.....	6.67	14.56	7.57	" " "
88. Main greensand bed three feet thick, Mulberry	.....	2.63	5.74	.....	" " "
89. Phosphatic limerock, Mulberry	1.97	2.10	4 52	.....	" " "
90. White Phosphatic marl, Day's Bend	43.79	4.10	8.95	.....	" " "
91. Phosphatic casts and nodules, Day's Bend	19.52	20.77	45.34	.....	" " "
92. Nodules, near Prattville	.....	28.14	61.34	.....	E. M. Harris, Univ. of Ala.
93. Nodules, near Prattville	.....	32.00	66.76	.....	" " "
94. Phosphatic shell rock, A. S. McKeithen, near Prattville	52 72	11.24	24 49	.....	D. W. Langdon, " "
95. Matrix rock, Bear creek, " "	29.48	2.71	5 92	.....	" " "
96. Greensand marl, " "	54.72	1 37	2 99	.....	" " "
97. Greensand marl, near Wetumpka	66 15	1 52	3 31	4 38	Laboratory A. & M. College.
98. White phosphatic marl, near Wetumpka	41.36	1.11	2.42	32.11	" " "
99. Clayey phosphatic marl, near Wetumpka	34 68	1.96	4.28	...	D. W. Langdon, Univ. of Ala

It has already been said above that Prof. Leroy Broun, Jr., of Auburn, was sent to examine the phosphatic deposits in the eastern part of the state. His report to Prof. Stubbs is given in full in Bulletin No. 5 of the Agricultural Commission, and from this report I take the following notes:

The phosphatic formation was first recognized by Mr. Broun on the place of Mr. T. L. Nobles, S. 36, T. 17, R. 23, and it consists of a greensand underlying the superficial loams and clays. The same greensand was also found at several other localities, as at Mr. Frank Howard's, S. 22, T. 16, R. 23, also a mile east of Mr. Howard's and on the Mr. J. M. Comer's place, four miles southeast of Tuskegee. Thence eastward the greensand bed was traced to Smith's Store, to within one and a half miles south of Society Hill, and within one mile of Marvin. The analyses which are presented (page 475) of the specimens collected by Mr. Broun, show that the marl is not very strongly phosphatic, and being moreover deeply covered by the sands of a later formation, is not likely to become of much importance.

The measurements of Mr. Broun show that the greensand is quite thick, averaging perhaps over six feet.

3. *Macon and Russell Counties.—Specimens Collected by Prof. Leroy Broun, Jr.*

	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Analyst		
100. Greensand, T. L. Noble's, Macon county	80.90	.45	.98	Laboratory A. & M. College.		
101. " F. Howard's, near Tuskegee	74.90	.31	.67	"	"	"
102. " Charlie Cr——, Calebee swamp	66.71	.77	1.68	"	"	"
103. " from well near Tuskegee	75.67	.59	1 28	"	"	"
104. " shell marl, A. Smith, near Uchee	74 46	.59	1.28	"	"	"
105. " J. M. Comer's, near Tuskegee, first 8 inches	71.35	1.29	2.81	"	"	"
106. " J. M. Comer's, near Tuskegee, average of five samples, taken at depth down to eight feet *	78.78	.50	1.09	"	"	"
107. Ferruginous sand, below Comer's greensand	82.25	70	1.52	"	"	"
108. Phosphatic rock, J. P. Morris', Society Hill	10.77	5.34	11.65	"	"	"
109. Greenish loam, Chattahoochee river, mouth of Uchee creek	71.00	.96	2.09	"	"	"
110. Blue clay, mouth of Uchee creek, Chattahoochee river	77.26	.21	.45	"	"	"

* In these samples the percentage of phosphoric acid decreases regularly with the depth.

2. THE LIVINGSTON, FORT DEPOSIT, UNION SPRINGS BELT.

The rocks of this belt crop out across the state, along the southern border of the prairie region, just as those of the first named belt, appear as a border along the northern edge of the prairies.

The localities are, of course, very numerous, and as some of the rocks, especially the hard crystalline limestone, appear to contain uniformly a high percentage of phosphoric acid, the aggregate amount of this substance is very great.

The mode of occurence of the phosphoric acid in the rocks of this belt is somewhat similar to that above described, viz: It is found impregnating the silicious limestone and white calcareous marls, as well as greensand marls, and is also seen in concretionary masses of nearly pure phosphate of lime, and in the moulds and casts of fossils, which are all strongly phosphatic, having nearly the same composition as the nodular phosphates themselves. It is interesting to note in this connection that wherever the original substance of the shell is present in any of these fossil remains, as is the case with the *exogyras and gryphæas*, of the oyster family, so abundant throughout the prairie region, there is scarcely a trace of phosphoric acid.

In the vicinity of the Tombigbee and Alabama rivers the upper or Ripley group of the Cretaceous consists of the following well marked divisions:

First. Yellow sands about fifty feet, holding in many localities large beds of highly phosphatic shell casts.

Second. Dark gray micaceous sandy clays and clayey sands, about 100 feet thick, traversed by hard ledges of similar materials, and not very prolific of fossils. In these beds we find at many localities a bed of phosphatic greensand full of soft pulverized carbonate of lime. This greensand is some three feet or more in thickness, contains about 1.5 per cent. of phosphoric acid, and has been very successfully used as a fertilizer. This is probably the most important of the phosphatic materials occuring in this belt, and sev-

eral analyses are given below, from which its composition may be seen.

Third. Thirty to thirty-five feet of a bluish argillaceous limestone, with great numbers of Cretaceous shells, which are, however, mostly in the form of casts, and strongly phosphatic. Along with these are irregularly shaped nodules of phosphate of lime, similar to those occurring in the Hamburg belt, and in most of the localities examined we find below this fossiliferous bed a stratum of silicious limestone of very variable thickness, which also is strongly impregnated with phospate of lime. It is quite possible also that some of the hard bands which traverse the sands next to be described are also phosphatic.

Fourth. Some sixty feet or more of sands of various colors, with indurated bands passing though them. As a rule, these sands are not very markedly fossiliferous, but the hard ledges usually hold great numbers of *exogyras* and *gryphæas*. As stated above, it seems probable that some of the silicious phosphatic rocks, of which analyses are given (page 485), belong to this division of the Ripley. This seems all the more probable from the fact that the uppermost strata of the Rotten Limestone itself, which follow next below the sands in question, hold in some cases a very notable percentage of phosphoric acid. This is shown by the analyses of specimens collected from the vicinity of Livingston. These specimens were all taken from the surface, and appear to be in most cases only the crumbling or disintegrated portions of the Rotten Limestone, and yet when the compact rock immediately underlying these phosphatic fragments is examined, it usually shows a very small proportion of phosphoric acid. In all cases the shell casts were phosphatic. The specimens about Livingstone were collected by the writer in company with Dr. R. D. Webb, whose knowledge of the geological and topographical features of Sumter county is extensive as well as accurate. Many years ago Dr. Webb made analyses of some of these very materials, and in the newspapers called attention to the comparatively large percentage of phosphoric acid which they contained.

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Fourth. Some sixty feet or more of sands of various colors, with indurated bands passing though them. As a rule, these sands are not very markedly fossiliferous, but the hard ledges usually hold great numbers of *exogyras* and *gryphæas*. As stated above, it seems probable that some of the silicious phosphatic rocks, of which analyses are given (page 485), belong to this division of the Ripley. This seems all the more probable from the fact that the uppermost strata of the Rotten Limestone itself, which follow next below the sands in question, hold in some cases a very notable percentage of phosphoric acid. This is shown by the analyses of specimens collected from the vicinity of Livingston. These specimens were all taken from the surface, and appear to be in most cases only the crumbling or disintegrated portions of the Rotten Limestone, and yet when the compact rock immediately underlying these phosphatic fragments is examined, it usually shows a very small proportion of phosphoric acid. In all cases the shell casts were phosphatic. The specimens about Livingstone were collected by the writer in company with Dr. R. D. Webb, whose knowledge of the geological and topographical features of Sumter county is extensive as well as accurate. Many years ago Dr. Webb made analyses of some of the materials, and in the newspapers called attention to the comparatively large percentage of phosphoric acid contained.

It seems further probable that throughout the Rotten Limestone there are beds in which the proportion of phosphate of lime is very considerable, or in which at least the shell casts are strongly phosphatic. This is shown by the analyses given (page 485) of phosphatic shell casts obtained from Boligee in Greene county, and from a locality between Newbern and Uniontown, seven miles from the first named place. Both of these localities are situated at some distance from the border of the Rotten Limestone.

Analyses illustrating the composition of the phosphatic materials occurring in the Rotten Limestone itself are given in the table (page 485), numbers 111 to 120 inclusive.

The phosphates of the strata which overlie the Rotten Limestone and which are included in the Ripley group have been examined from a number of localities below noted, and their description may perhaps be best given in geographical order. In describing the specimens, I shall endeavor to mark, as far as it is possible to do so, their geological position also by referring them to one of the four divisions of the Ripley group given on a preceding page.

Sumter County.—At Livingston, in addition to the phosphatic materials already mentioned as occurring in the Rotten Limestone itself, there is, at the negro graveyard about two and a half miles southeast of town, an outcrop of a silicious limestone or calcareous sandstone strongly phosphatic, and a good many feet below it a clayey limestone with about half a per cent. of phosphoric acid. The silicious rock lies upon a hill of considerable height, and probably belongs to the upper part of the fourth or the lower part of the third division above given. The argillaceous limestone probably belongs to the Rotten Limestone. Analyses of these rocks are given in the table (page 485), numbers 118 and 121. Just across the ridge over Sucarnochee, on the road to York, the argillaceous limestone with phosphatized shell casts (third division above) outcrops along the road leading up the hill. None of these have been analyzed, but they are of the usual character.

At Coatopa the same clayey limestone may be seen on the land of Mr. John Wiatt. This rock has a good deal of glauconite and is highly fossiliferous, the fossils being mostly in the form of phosphatized casts. Analyses both of the limestone and of the shell casts have been made, numbers 122 and 123. In the same locality there is a highly calcareous greensand marl, full of lumps of pulverulent carbonate of lime. This material, by reason of its comparatively high percentage of phosphoric acid, as well as of carbonate of lime, will made an excellent fertilizer, where it can be had without much cost for freight. Analyses, numbers 124, 125 and 126, (page 485).

At Moscow, on the Tombigbee River, the strata of this horizon outcrop on the banks of the river. Here we have the silicious rock, the clayey limestone and the shell casts, and a few miles north of the town, at Dr. Kelley's, the greensand marls. Analyses, numbers 127, 128, 129, (p. 485).

Marengo County.—In Marengo county the rocks of this horizon may be followed along a line leading from Moscow through Jefferson, Nixon's Store, etc. They occur near C. C. Shields, south of Dayton, and all along the Linden and Prairie Bluff road to the eastern border of the county. The materials which have been analyzed come, in this county, from two horizons, viz: The upper strata of the Rotten Limestone or the immediately overlying beds of the Ripley, and the sandy beds which form the uppermost division of the Ripley as above indicated.

1. Immediately south of the town of Dayton the soil is a strongly tenacious calcareous clay, imbedded in which are numerous clayey phosphatic concretions which are different from anything seen elsewhere. If found in sufficient quantity, these could no doubt be utilized, since they contain a very considerable percentage of phosphoric acid, as shown by the subjoined analyses, numbers 130 and 131, (page 485).

2. In the uppermost beds of the Ripley group, which are in the main yellow micaceous sands, there are at intervals beds of shells, or rather of the casts of shells, in some cases

five or six feet in thickness. These shell casts are almost pure phosphate of lime, and as they are loosely imbedded in the sands and in large quantity, they may undoubtedly be dug out, ground up and used with profit. Near Mr. Bailey's, between Dayton and Linden, there is at the Capt. Saunders place a thick bed densely packed with these shell casts. Also near C. C. Shields, on the road to Prairie Bluff, and on the Shiloh road there are many cuts worn by the roads in the yellow sands, and in these cuts these shell beds appear. An analysis of some of the casts from this locality appears on page 485, number 132.

Further south also in T. 15, R. 4, in a belt running east and west through the second tier of sections of the township, these shell beds are met with in many localities. One of the analyses (page 485) shows the composition of an average of the shell casts from three localities on Thos. Boozer's land. Number 133. These, as well as most of the clayey phosphates from near Dayton, were collected by Mr. Lawrence R. Smith, to whom I am also indebted for much information concerning the occurrence of the phosphatic material in Marengo county.

These shell casts appear to promise more than any of the other materials observed in Marengo, for they are found in sufficient quantity, are easily accessible, and if the composition in other localities is approximately similar to that of the specimens analyzed, they are rich enough in phosphoric acid. It seems probable that they will all be found to be very highly phosphatic, since the specimens from near Rehobeth from the same geological horizon show a similar composition. See analysis number 139, (page 45.)

Wilcox County.—This phosphatic belt may be traced all along the northern border of the county from Prairie Bluff to Snow Hill. The phosphates appear to come from three distinct geological horizons, viz:

1. The argillaceous limestone with shell casts which make up the third division of the Ripley group. Everywhere at this horizon hard brown colored shell casts of phos-

phate of lime are seen wherever the limestone has been exposed to weathering. Samples of these phosphatic casts have been collected from Prairie Bluff, Old Canton Landing and vicinity, near Bridgeport, at mouth of Tear Up Creek, and eastward out to Snow Hill, and associated with them at all these localities we find hard crystalline phosphatic limestone and calcareous sandstone, the limestone being in places very silicious, so as to approach sandstone in composition. We have no analyses of the shell casts from Wilcox, but they are in all respects like those from Coatopa and other localities along this belt. At Prairie Bluff there is a sandstone much used for building purposes, which has a good deal of phosphoric acid, averaging perhaps .5 of a per cent. See analysis (page 486), No. 134.

The silicious limestone, which may be a variety of the preceding, is more strongly phosphatic, and a specimen from a locality about a mile north of Prairie Bluff contained over 8 per cent. phosphoric acid. No. 135. A similar phosphatic sandy limestone from John Pettway's land, in Gee's Bend, has even more. See No. 137, (page 486.)

A somewhat similar rock, but less strongly phosphatic, was analyzed from Mr. J. T. Beck's land near Bridgeport. No. 136, (page 486.)

Again, at Snow Hill the same rock, a specimen of which from L. Moore contains nearly 10 per cent. No. 142, (page 486.)

2. In the upper strata of the Ripley group in all these localities occur the phosphatic shell casts, analogous to those described from near Shields', in Marengo, and in the eastern part of the county near Snow Hill, the phosphatic greensand, which is probably analogous to that occurring at Coatopa and near Moscow. Some of the shell casts from Rehobeth, a few miles north of Prairie Bluff, have been analyzed and contain over 23 per cent. of phosphoric acid. No. 139. Associated with these casts are numerous rounded lumps of a sandy calcareous character containing some phosphoric acid. No. 138, (page 486.)

The greensand has been best tested, both by analysis and by actual field experiment, from the bed occurring at W. S. Purifoy's, Snow Hill. This contains about 1.5 per cent. of phosphoric acid, but a large percentage of carbonate of lime in loose, easily crumbled form, and will be one of the most valuable of natural fertilizers where it can be spread upon the soil without too much expense. See No. 140, (page 486.) This is analogous to the greensand marl from near Coatopa, and from various localities in Dallas contiguous to the Wilcox line, as shown below.

There is an indurated bed usually associated with the greensand which contains even a higher percentage of phosphoric acid. as may be seen from the analysis No. 141, (page 486.)

Dallas County.—The same rocks occur along the southern line of this county at Tilden, Richmond, Carlowville, Minter Station, etc., where we find both the greensand bed and below it the silicious phosphatic limestone or calcareous sandstone, of which several analyses are presented. From these it will be seen that the limestone has a very variable composition. Nos. 144, 145, 146, 147, 151, 152, 154, (pages 486-7.) With this are everywhere found phosphatic shell casts. No. 153, (page 487.) The greensand marl appears to be of more uniform composition, as shown by analyses Nos. 143, 148, 149, 150, (pages 486–7.)

Lowndes County and Eastward.—Beyond Dallas county very few examinations have been made, but some specimens have been sent to the University which show the existence of this line of phosphatic rocks nearly to the eastern line of the State. The phosphatic greensand crosses Lowndes a short distance below Bragg's Store.

Between Fort Deposit and Calhoun Stations the silicious limestone occurs sometimes in rounded, apparently water-worn fragments, one of which has been analyzed. No. 155, (page 487.

Again, at Strata, in the northern part of Crenshaw county, we find the same rock. Analysis No. 156, (page 487.) Along with it are great numbers of phosphatized shell casts.

At Olustee Creek, in northern Pike, a limestone with a moderate proportion of phosphoric acid has been found, but the main phosphatic belt will probably be found further north in the lower part of Montgomery county. See analysis 157, (page 487.)

The crystallince limestone of Chunnenugga Ridge at Union Springs, in Bullock county, is also phosphatic, as well as the limestone cropping out on the banks of Cubahatchee Creek in Macon county. No. 162 and 163, (page 487.)

From Dr. C. B. Leitner, Flora, Bullock county, I get a number of specimens of a phosphatic clay marl, which although not very rich in phosphates, might yet be advantageously used where the cost of transportation and application to the soil would not be too great. For analyses see Nos. 158, 459, 160, 161, (page 487).

Along the Chattahoochee river, phosphates, nodules, etc., have been observed in small quantities at several places, *e. g.*, near the mouth of Uchee Creek, on Mr. Blackman's place above Eufaula, etc., but no analyses have yet been made of them.

The tables on pages 485-7 show at a glance the composition of the various materials above mentioned. They are arranged first, as to their geological horizon, and secondly, as to geographical position. The several materials are (beginning with the lowermost, geologically): 1st, a silicious limestone of very variable composition, with which are associated numerous phosphatized shell casts. This appears at Moscow, at Prairie Bluff, in Gee's Bend, at Minter Station and at Snow Hill.

Above this we find in many of the localities a fine greensand marl containing about 1.5 per cent of phosphoric acid, *e. g.*, at Coatopa, near Moscow, at Tilden, and at Snow Hill. At Eufaula the dark gray micaceous marls have a small percentage of phoshoric acid. Analyses 164, 165, 166, p. 487. In these micaceous sands the greensand bed is located. The greensand is the most valuable of all the materials occur-

ring in the Upper Cretaceous, unless it should turn out that the shell casts occurring in the uppermost sands (*e. g.*, at C. C. Shields' and Bailey's, in Marengo, and near Rehobeth in Wilcox,) are present in very great quantity, and, as now seems to be the case, very generally distributed throughout the country. This bed lies at a considerable distance above the silicious limestone and shell casts above mentioned, the distance between the two being probably over 100 feet The casts themselves are easily pulverized, unlike those occurring in the lower bed.

Phosphatic Materials from the Livingston, Coatopa, Snow Hill and Union Springs Belt.

NUMBER AND NAME.	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate	Lime.	ANALYST.
A.—Rotten Limestone.					
111. Nodules and shell casts, 7 miles south of Newberne....	3 59	20.68	45.16	.....	A & M. College Laborat'y
112. Fossil casts from Boligee.....	2.98	27.76	49.68	.....	" " "
113. Near railroad bridge in Livingston.....	11.90	.20	.43	.....	" " "
114. Hill, 3¼ miles from Livingston, on Jones' Bluff road...	53.16	.41	.86	.....	" " "
115. Silicious lime rock 4½ miles north of Livingston.....	39.52	.50	1.09	.....	" " "
116. Concretionary nodules 3¾ miles north of Livingston...	8.48	1.10	2.60	.....	" " "
117. White clayey limestone 4m. s-e. of Livingston, J. J. Lee's	13.90	2.58	5.62	.....	" " "
118. Clayey limestone, Negro graveyard, 2½ m. s-e. Liv'ston.	25 30	.56	1.22	.....	" " "
119. Clayey limestone, 6 m. s-e. Livingston, Black Bluff road	15.02	.64	1 39	.....	" " "
120. Phosphatic shell casts, same l cality as 119.....	11.65	9.92	21.65	....	" " "
B.—Ripley Group, Overlying Rotten Limestone.					
121. Silicious rock, Negro graveyard, 2½ miles s-e. Livingston, Sumter county.....	.....	7.30	15.91	.....	Eugene A. Smith.
122. Shell casts and nodules, Jno. Wiatt's Coatopa.....	9.38	14.56	31.78	.....	A. & M. College Laborat'y.
123. Clayey limestone with greensand, same locality	25 74	5.01	10.93	.....	" " "
124. Clayey phosphatic marl, same locality.....	51.25	2.24	4.89	.....	" " "
125. Clayey phosphatic arl, another variety, same locality.	.....	.72	1.57	.....	Eugene A. Smith.
126. " " " " " "	.....	.74	1.61	.....	" "
127. Silicious rock, river bluff, below Moscow, Sumter co..	57.00	.28	.53	.....	A. & M. College Laborat'y.
128. Shell casts, " " "	25 52	1.55	3.38	.....	" " "
129. Greensand marl, Dr. Kelly's, few m. n of Moscow, "	.....	2.52	5.50	.....	" " "
130. Clayey concretions, white, in soil just south of Dayton, Marengo county.....	11:02	10.93	23.83	.....	D. W. Langdon, Jr
131. Clayey concretions, dark gray, just south of Dayton, Marengo county.....	21.41	17.32	37.76	.....	" "
132. Shell casts, C. C. Shield's, near Dayton, Marengo county.....	.....	19.00	41.62	.....	Eugene A. Smith.

Phosphatic Materials from the Livingston, Coatopa, Snow Hill and Union Springs Belt.—Continued.

NUMBER AND NAME.	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	Analyst.
133. Shell casts, T. J. Boozer's, T. 15, R. 4, Marengo county	.....	25.43	55.48	.....	Eugene A. Smith.
134. Calcareous sandstone, average of three analyses Prairie Bluff, Wilcox county	.....	.48	1.05	.....	" "
135. Calcareous sandstone, one mile north of Prairie Bluff, Wilcox county	.....	8.35	18.20	.....	" "
136. Gray calcareous rock, J. T. Beck, near Bridgeport, Wilcox county	.....	1.08	2.34	.....	" "
137. Phosphatic limestone, J. H. Pettway, Gee's Bend, Wilcox county	.....	12.49	27.23	.....	" "
138. Sandy calcareous lumps, near Rehoboth, Wilcox county	.....	.40	.87	.....	" "
139. Phosphatic shell casts, near Rehoboth, Wilcox county	.....	23.52	51.28	.....	" "
140. Phosphatic greensand, W. S. Purifoy, Snow Hill, Wilcox county	40.83	1.04	2.27	.....	D. W. Langdon, Jr.
141. Indurated greensand, W. S. Purifoy, Snow Hill, Wilcox county	28.61	3.94	8.59	.....	" "
142. Sandy phosphatic limestone, L. Moore, Snow Hill, Wilcox county	32.47	9.74	21.23	.....	" "
143. Phosphatic greensand, J. B. Lang, Tilden, Dallas county	.....	1.50	3.27	16.36	Eug. A. Smith.
144. Glauconitic limestone, J. Z. Hearst, Richmond, Dallas county	15.78	2 62	5.72	.....	A. & M. College Laboratory.
145. Siliceous limestone, J. Z. Hearst, Richmond, Dallas Co.	84.95	3.21	7.00	.....	" " "
146. Siliceous limestone, J. Z. Hearst, Richmond, Dallas Co.	40.16	5.94	12.96	.....	" " "
147. Siliceous limestone, Dr. G. W. Kyser, Richmond, Dallas county	39.47	3.69	18.97	29.31	" " "
148. Greensand marl, Dr. G. W. Kyser, Richmond, Dallas county	35.23	1.43	3.23	18.66	D. W. Langdon, Jr.
149. Greensand marl, Dr. G. W. Kyser, Richmond, Dallas county	37.98	1.24	2.70	16.88	" "

Phosphatic Materials from the Livingston, Coatopa, Snow Hill and Union Springs Belt—Continued.

NUMBER AND NAME.	Insoluble Matter.	Phosphoric Acid.	Bone Phosphate.	Lime.	ANALYSIS.
150. Greensand marl, from Wade, Carlowville, Dallas county	37.20	1.16	2.53	17.92	D. W. Langdon, Jr.
151. Glauconitic limestone, H. M. Smith, Minter Station. Dallas county	17.38	.74	1.62	.....	A. & M. College Laboratory.
152. Silicious limestone, Col N. H. R. Dawson, Minter Station, Dallas county	42.46	1.43	3.12	.....	" " "
153. Phosphatic shell casts, Col. N. H. R. Dawson, Minter Station, Dallas county	10.72	16.90	36.89	.....	" " "
154. Phosphatic limestone, Col. N. H. R. Dawson, Minter Station, Dallas county	.....	12.41	27.05	.....	John Daniel.
155. Sandy crystalline limestone, Ft. Deposit, Lowndes Co.	.....	13.55	29.54	.....	Eugene A Smith.
156. Sandy crystalline limestone, Strata, Crenshaw county.	.....	6.22	13.56	.....	Eugene A. Smith.
157. Sandy crystalline limestone, Olustee creek, Pike county	41.96	1.14	2.49	.....	A. & M. College Laboratory.
158. Dark colored clay marl, C. B. Leitner, Flora, Bullock county	87.25	.53	1.16	1.15	" " "
159. Yellow colored clay marl, C. B. Leitner, Flora, Bullock county	67.25	.81	1.76	12.02	" " "
160. Dark colored clay marl, C. B. Leitner, Flora, Bullock county	77.48	.76	1.66	8 20	" " "
161. Dark gray clay marl, C. B. Leitner, Flora, Bullock county	77.02	.66	1.44	12 32	" " "
162. Hard limestone, nine miles south of Tuskegee (mean of three analyses) Macon county	.....	.38	.82	.....	" " "
163. Hard limestone, on Cubahatchee creek, Macon county.	.....	.51	1.11	.....	" " "
164. Gray micaceous sandy marl, J. W. Tullis, Eufaula, Barbour county	80.14	.44	.96	.....	D. W. Langdon, Jr.
165. Light gray, indurated sandy marl, J. W. Tullis, Eufaula, Barbour county	.....	.18	.39	.....	" "
166. Gray micaceous sandy marl, J. W. Tullis, Eufaula, Barbour county	76 19	.27	.59	.....	" "

THE TERTIARY FORMATION.

General Characters and Sub-Divisions.

The whole thickness of the strata of the Tertiary formation on the Alabama and Tombigbee Rivers is between 1,600 and 1,700 feet, while on the Chattahoochee it is about 1,300 feet.

We have adopted the following four-fold division of the Tertiary:

(4) The White Limestone.
(3) The Claiborne.
(2) The Buhrstone, and
(1) The Lignitic.

The general characters of these sub-divisions are given below in the order of their relative ages, *i. e.*, beginning with the eldest.

(1) THE LIGNITIC.

This is the most massive of the sub-divisions of the Tertiary, having a thickness which can hardly be less than 900 feet. It also presents a greater variety in mineral composition, as well as in fossils, than the other divisions. In the most general terms, the Lignitic strata are cross-bedded sands, thin bedded or laminated sands, laminated clays and clayey sands, and beds of lignite, as well as lignitic matter which merely colors the sands and clays. With these are found inter-bedded at several horizons strata containing marine fossils. For the sake of greater convenience of description we present this Lignitic division in seven sections, each of which is characterized by one or more beds of marine fossils included in it. These sections are as follows, beginning with the lowest or oldest:

(a) The Midway or Pine Barren section; Clayton limestone.—The thickness of this section along the Alabama and Tombigbee Rivers is perhaps 25 feet. The strata are a white argillaceous limestone holding a large fossil of the nautilus family, which is characteristic of the horizon, calcareous sands and a crystalline limestone with *turritellas*, *carditas* and *corals*. This section is best seen in eastern Wilcox on Pine Barren Creek, and in adjoining part of Butler in the little Texas region, but the upper or Nautilus rock occurs at Midway on the Alabama River and westward across Marengo. In going eastward we find the rocks of this section increasing in thickness till on the Chattahoochee it includes over two hundred feet in thickness of limestones and other calcareous strata.

(b) The Black Bluff section.—We find some difficulty in determining the exact thickness of the strata of this section, since on the Tombigbee the strata outcrop over a surface which would, with uniform dip, correspond to a thickness of over two hundred feet; while on the Alabama, and more particularly inland in the eastern part of Wilcox county, the thickness is not greater than thirty five or forty feet. Since 80 feet of these beds are seen in superposition at one locality, (Black Bluff) we think that the maximum thickness cannot be less than one hundred feet.

The characteristic strata of nearly the whole of this section are black or very dark brown clays, which are in part fossiliferous. These clays underlie the *Flatwoods* of western Alabama and Mississippi, but towards the east they become much more calcareous and form the basis of some fine farming lands with black limy soils. This section has not been identified eastward of Butler county.

(c) The Naheola and Matthews' Landing section.—It is difficult to give the exact thickness of the strata of this section also, since it varies on the two rivers Alabama and Tombigbee, and thins down towards the east and does not appear at all on the Chattahoochee. We have placed the

thickness at one hundred and thirty to one hundred and fifty feet; the strata are gray sandy clays in the main, alternating with cross bedded sands. The beds of dark sandy and glauconitic clays containing marine fossils lie at the base of the section. At Naheola, on the Tombigbee, the upper and more glauconite part of the bed is most prominent, while at Matthews' Landing on the Alabama, the lower part of the bed, dark gray sandy clays form the bluff.

(d) The Nanafalia and Coal Bluff section.—The strata of this section are 200 feet in thickness and consist of about 50 feet of gray sandy clays at top, which show a tendency to indurate into tolerably firm rocks resembling very closely some of the strata of the Burhstone. Below this, about eighty feet of sand beds, often strongly glauconitic characterized throughout by shells of a small oyster, *Gryphæa thirsæ*. Near the base of this sandy division there is a bed about twenty feet thick literally packed with these shells. Below the Gryphæa thirsæ beds follow some seventy feet of cross bedded sands, glauconitic and apparently devoid of fossils, including about ten feet above the base of the section, a bed of lignite which varies in thickness from four to seven feet. The Nanafalia section retains its thickness and general character across the state to the Chattahoochee.

(e) The Bell's Landing of Tuscahoma section.—This is 140 feet in thickness on the Alabama and Tombigbee rivers, and this thickness is retained across the state to the Chattahoochee. The lithological characters also are practically the same throughout, but in the western part of the state the section includes two important beds of marine fossils and a third quite small and apparently unimportant. Towards the east these beds disappear. These fossiliferous beds are interstratified with yellowish sands in the upper and rather heavy bedded sandy clays in the lower part of the section. The upper marine bed, called the Bell's Landing marl, is about ten feet in thickness, and has forty feet of sandy strata over it. The middle bed is called the Gregg's Landing marl, and it is twenty to twenty-five feet below the

preceding; it is about five feet in thickness. The lowermost of the fossiliferous beds of this section is only about one foot in thickness and lies about fifty feet below the Gregg's Landing bed. It is highly glauconitic, but does not contain any great variety of fossils. The Bell's Landing marl is distinguished from all others in Alabama by the great size of the shells it contains. Eastward of the Alabama river there are very few fossils seen in the strata of this section.

(f) The Wood's Bluff or Bashi section.—This is 80 to 85 feet in thickness. The uppermost 30 feet consist of brown clays passing into a greensand, which holds a great variety of finely preserved marine shells. Below this greensand marl are dark gray sandy clays with four or five thin beds of lignite within the first twenty-five feet, succeeded by about 30 feet of cross-bedded sands, with a two foot seam of lignite at the base. This section extends entirely across the state to the Chattahoochee, where it is, however, considerably less in thickness and comparatively wanting in well preserved fossils.

(g) The Hatchetigbee section.—This section is 175 feet in thickness and is made up of sandy clays of prevailing brown colors varied with purplish shades, and containing three or four beds of marine shells in the uppermost 75 feet, and of somewhat similar purplish brown clays nearly devoid of fossils in the lower 100 feet. All these brown sandy clays become much lighter colored upon drying and exposure to the weather. These clays extend across the state with somewhat diminished thickness, till on the Chattahoochee they are perhaps not thicker than 50 feet and are practically devoid of fossils.

2. THE BUHRSTONE.

The minimum thickness of this formation is 300 feet; the materials are almost altogether aluminous and silicious consisting of aluminous sandstones, claystones and quartzitic sandstones, with occasional thin beds of glauconitic sand.

The new fossils which have been obtained from this division are mostly in the form of casts. They do not appear to differ specifically from that of the overlying division. On the Chattahoochee the thickness is less than 200 feet and the rocks are much more calcareous and hold a greater number and greater variety of fossils.

3. THE CLAIBORNE.

The thickness is 140 to 145 feet; the materials are sands and clays, which are generally calcareous and often glauconitic. Near the top of the sub-division is a bed of glauconitic sand, 15 to 17 feet in thickness, filled with shells in a perfect state of preservation. The sandy clays forming the lower 50 feet are likewise filled with a great variety of shells in a good state of preservation. The intervening calcareous clays end calcareous sands are distinguished by the great number of shells of *Ostrea sellæformis* which they hold, as well as by the comparative rarity of other forms. On the Chattahoochee the thickness is not greater than 75 feet, and the bed with Ostrea sellæformis appears to be the only representative.

4. THE WHITE LIMESTONE.

This subdivision is calcareous throughout, but the lowermost 60 feet are more argillaceous than the rest. The minimum thickness is 350 feet, of which the uppermost 150 feet consist of a tolerably pure but somewhat silicious limestone filled with coral masses.* The next succeeding 140 feet or more are made up of a soft white limestone, often quite pure and filled with *Orbitoides Mantelli*. The lowermost 50 feet are of impure, argillaceous limestone, which is disintegrating yields a black calcareous soil similar to that derived from the Rotten Limestone of the Cretaceous. This lower portion of the White Limestone surpasses the others in variety

*This upper part appears to be entirely local and has not been seen except in Clark county, below Jackson. Leaving this out of account, the thickness of the White Limestone is some 200 to 300 feet.

of its fossil contents. On the Chattahoochee the rocks are more uniform in composition and are about 275 feet in thickness.

Phosphates of the Tertiary Formation.

In the summer of 1884, Mr. D. W. Langdon, Jr., of the State Geological Survey, discovered at St. Stephens, and subsequently at several other localities, representing different geological horizons, phosphatic marls and nodules. Since that time other examinations have disclosed the fact that phosphatic material exists in at least four different geological horizons, viz: In the Black Bluff and Nanafalia groups of the Lignitic; in the White Limestone; and in eastern Alabama, at Ozark, in the strata of the Claiborne group.

1. *Black Bluff Group.*—In the eastern part of Wilcox county the prairie clays derived from the disintegration of this group are highly fertile, and though no analysis of any of these soils has yet been made, it is probable that they are exceptionally strong in phosphoric acid, for they are in places filled with irregularly shaped concretions or *coprolites* which are chiefly phosphate of lime. One of these specimens analyzed by me, from the mouth of Bonner's Lane, contains 27.632 per cent. of phosphoric acid, equivalent to 6.238 of bone phosphate. Analyses No. 167 (page 497). Immediately above the clays here alluded to are several sandy beds, which, in part, are pretty firm sandstones. One of these sandstone beds is more persistent than the others, and appears along the hillsides, near Allenton and elsewhere in eastern Wilcox, in little cliffs which look like low walls. This rock has in places a large number of phosphatic concretions, very like those above described as occurring in the clays below. I have made two analyses of this rock, the one from the "Grave Yard Hill," a few miles west of Allenton on the upper Camden road, and the other from the mouth of Bonner's Lane. Both are hard, yellowish, sandy limestones, that from the first locality being pretty free from the phos-

phatic nodules, that from the other containing a notable quantity of them. The rock from the Grave Yard Hill had 0.3 per cent of phosphoric acid only, while that from Bonner's Lane contained 3.71 per cent. Analyses No. 168, 169, (page 497).

This formation runs eastward into Butler, where, however, it has not as yet been examined.

2. *The Nanafalia Group.*—The important bed in this division of the Lignitic is a deposit of shells of a smaller oyster, called *Gryphæa thirsæ*. While this shell is found generally distributed through sixty feet or more of the strata, there are in most localities of its occurrence beds from 15 to 20 feet in thickness, consisting of an almost solid mass of these shells packed in greensand. At intervals in these beds there are bands much harder than the rest of the beds, and these hardened bands appear to be generally pretty strongly phosphatic. Mr. Langdon analyzed a specimen from Nanafalia of one of these hard ledges and found 6.701 per cent. of phosphoric acid in it. Analyses No. 170, (page 497).

The softer parts of this marl, as well as of the other marls which characterize the Lignitic division of the Tertiary, appear, as a rule, to have a very inconsiderable percentage of phosphoric acid. Several of them, however, would make good fertilizers because of the large amount of pulverulent carbonate of lime which they hold; especially is this the case with the Nanafalia and Wood's Bluff marls.

3. *The Claiborne.*—In the eastern part of the state the Claiborne division of the Tertiary includes in places a bed of shell marl, which holds a very considerable percentage of phosphate of lime. This bed is best seen in the cut made by the Midland railroad, a short distance from Ozark, in Dale county, where this road passes under the Savannah & Western R. R. Georgia Central. This bed about five feet in thickness contains also a large amount of carbonate of lime, and would unquestionably benefit the soils about Ozark if spread liberally upon them.

The section exposed here is as follows :

(1)	Gray surface sands	3 to 4 feet.
(2)	Red clay loam	6 to 8 "
(3)	Light colored laminated clay	5 "
(4)	Dark bluish pyritous sands	5 "
(5)	Black or dark gray joint clay	3 "
(6)	Greensand marl filled with shells, which are mostly of one species, a *cytherea*. This bed is phosphatic	5 "
(7)	Black sandy clay to bottom of the cut	4 "

The bed No. 6 is the one referred to, and though it has been seen by me only at this place, there is no doubt that it underlies a large area and will be found outcropping along the ravines about Ozark.

4. *The White Limestone.*—In the lower beds of this formation at St. Stephens, Mr. Langdon first saw the phosphatic marl. It occupies the lower fifty or sixty feet of the division, corresponding to the Jackson formation of Hilgard and other writers. In this limestone there are phosphatic marls, as well as nodular masses of phosphate of lime. Where the disintegrated marl forms the surface, a very productive and lasting soil is the result. The fertility of the soils of the "Lime Hills" of Clarke, Washington and Choctaw counties is well known, and the same class of soils is found in the prairies of Western Mississippi, which join the lime hill regions of Washington and Choctaw. In this state the topography of the region is rather broken, so that the soil washes badly.

The marl first analyzed from St. Stephens contains 1.14 per cent. of phosphoric acid, and a nodular mass from the same locality contains 22.68 per cent., or about as much as the average nodules of the Cretaceous formation. No. 171 and 172, (page 497).

A cream colored calcareous rock from near Coffeeville, of presumably the same horizon, contains 2.743 per cent. No. 173, (page 497).

In many places in Clarke county, where the lower part of the White Limestone forms the surface, these nodules are common. One has been analyzed from near Grove Hill, having 19.48 per cent. of phosphoric acid. No. 174 (page 497). I have, however, nowhere seen them in sufficient quantity to make them of any importance. The marl, on the other hand, might be very advantageously used where it is convenient to the fields upon which it could be spread without too great a cost.

The upper part of the White Limestone seems to be comparatively barren of phosphatic materials. The average of a good many analyses made of this rock shows no more than about 0.1 per cent. of phosphoric acid.

So far as examined up to this time, none of the Tertiary materials of Alabama are very promising for phosphates. Florida, on the other hand, abounds in phosphatic limestone and marl, but they are, in all probability, in every case, of Miocene age, later than the Tertiary of Alabama. Examinations made of the Eocene limestone of Florida (of same age as the Alabama rock) likewise show very little of phosphoric acid.

None of the materials from the Claiborne and Buhrstone divisions, except the shell bed at Ozark, Dale county, above mentioned, have as yet shown any notable amount of phosphate.

The following table will show the composition of the phosphatic materials from the Tertiary formation:

Table of Analyses of Phosphatic Materials from the Tertiary Formation of Alabama.

NAME AND LOCALITY.	Insoluble Matter.	Phosphoric Acid.	Bone Ph'sphate	Lime Carbonate.	ANALYST.
167. Phosphatic nodule, Lignitic group, Bonner's Lane, Wilcox county	.....	27.63	60.24	.....	Eug. A. Smith.
168. Phosphatic sandstone, Lignitic group, Bonner's Lane, Wilcox county	.....	3.71	8.00	.....	" "
169. Phosphatic sandstone, Lignitic group, near Allenton, Wilcox county	.....	.30	.65	.....	" "
170. Indurated marl, Lignitic group, Nanafalia, Marengo county	19.31	6.70	14.61	.....	D. W. Langdon, Jr.
171. Phosphatic marl, white limestone, St. Stephens, Washington county	12.00	1.14	2.47	68.82	" "
172. Phosphatic nodule, white sandstone, St. Stepheus, Washington county	4.51	22.68	49.45	18.79	" "
173. Phosphatic rock, white limestone, near Coffeeville, Clarke county	6.44	2.74	5.98	72.01	" "
174. Phosphatic nodule, white limestone, Grove Hill, Clarke county	5.55	19.48	42.47	.....	" "

PROBABLE ORIGIN OF PHOSPHATES.

The phosphates above described, especially those of the Cretaceous formation, in their geological position, mode of occurrence, and in the character of the material, resemble the phosphates of Cambridgeshire, England. These are found at several horizons in the formations immediately underlying the Chalk, viz: the Upper Greensand, the Gault, and the Neocomian, or Lower Greensand; the phosphate or "coprolite" beds appear always to mark horizons of unconformity, i. e., they seem to have been deposited upon the eroded surfaces of previously existing strata; they consist of casts of shells, bones, etc., mineralized by phosphate, and of shapeless masses of phosphate of lime; they are irregularly distributed through the matrix along with pebbles and other rolled masses; and many of the phosphatized casts are of fossils which belong to earlier formations than those of which they now form a part. (See T. G. Bonney, Cambridgeshire Geology, and W. Keeping; the Fossils of Upware, etc.)

So our Alabama phosphates of the Cretaceous formation occur at several horizons, and they occur at planes of unconformity. This is particularly noticeable in the case of the phosphates at the base of the Rotten Limestone. In western Alabama, along the Tombigbee River, from 800 to 1000 feet of Lower Cretaceous beds underlie the Rotten Limestone, the northern outcrop of which is at least thirty miles from the Coal Measures at Tuscaloosa, while eastward these underlying beds seem to thin out so that at Wetumpka the phosphate bearing beds almost lap over upon the Metamorphic rocks.

The fossil casts are worn into most irregular shapes, and are associated with the bones of saurians and the teeth of sharks. These phosphates are mingled with rolled or waterworn fragments of other rocks; especially is this the case in

the southern phosphate belt. At Fort Deposit, or just south of it, is a ridge which owes its existence to the hard crytalline limestone of the Ripley group; the foot of this, and the plain north of it for several miles, are strewn with rounded and water-worn fragments of this silicious limestone.

The specimen from Fort Deposit, of which an analysis is given above, was one of these rounded and water-worn fragments.

The same thing may be noticed at Strata, and probably at very many other similar localities. Speaking of the Chunnenuggee Ridge at Union Springs, Prof. Toumey says: "The north side of the ridge presents the appearance of an ancient sea-beach, waterworn, detached masses of limestone and calcareous sandstone, imbedded in sand, and presenting the appearance of having been washed for ages by the ocean waves." (2d Report on the Geology of Alabama, p. 136.)

It is thus seen that in all these respects the Alabama Cretaceous phosphate beds resemble those of England, and it is quite probable that many of the phosphatic shell casts are "derived" fossils, that is, they have been washed out of the beds of which they originally formed a part, and redeposited in the beds where they are now found. To decide this question a thorough study of our Cretaceous fossils will be needed.

In South Carolina a very similar state of things exists, only the main phosphate beds are of Tertiary, or later, instead of Cretaceous age.

The explanation of the origin and mode of formation of the phosphatic deposits now most generally accepted, is that originally presented by Prof. Holmes, of Charleston, which is thus well summarized by Dr. U. C. Shepard, Jr.: "Accumulations of decomposed animal detritus and exuviæ were acted upon by carbonic acid water, which dissolved out the phosphates and transported them into calcareous earth, where they were precipitated and fixed by carbonate of lime.

This process was continued till the carbonate of lime was transformed into a rich phosphate of lime. The mass, originally soft and loose, hardened gradually, but under the wear and roll of water it was broken up and rounded into the phosphatic pebbles now found."

Prof. T. G. Bonney (Geology of Cambridgeshire) has given the following account of the process: "With regard to the mode of formation of these phosphatic casts, nodules, etc., we have to consider not only the probable source of the phosphate, but also the mode in which it has been concentrated into these "coprolites." Phosphate of lime in the form of the mineral *Apatite* is present in granite, gneiss, slate, talc, and chlorite schists, and several kinds of lava. . . It is also present in the waters of numerous mineral springs. . . "It has been detected in the waters of several rivers, and is probably present in all, as well as in the sea, though of course in small quantities. Again, phosphates (chiefly lime) are present in marine and other plants. In short, the various investigations that have been made show that it is almost universally present in organic and not unfrequently in inorganic bodies."

"Next, it has been shown by numerous experiments that phosphate of lime is soluble in carbonated water, and further, that phosphate of lime present in an organism, (plant or animal) is much more soluble than that in a mineral."

"Again, phosphate of lime dissolved in carbonated water is precipitated by ammonia, which is a result of decomposition of organic bodies. It appears, then, to me, that the best explanation of these phosphatic nodules is to consider them formed by what, for want of a better name, we may call concretionary action. The excreta, softer tissues, and smaller bones of the Vertebrata, the bodies of numerous Invertebrata, many of which have left no other trace behind, the various marine plants which probably would flourish

abundantly in a shallow sea, to say nothing of any apatite which might be present in the detritus wherein they were entombed, would furnish a considerable supply of phosphates; in fact, *cæteris paribus*, a shallow sea appears to me more likely to be rich in phosphates than a deep one. The phosphates of the more perishable parts of the above named organisms would be dissolved in the water permeating the mud of the sea bottom, which would also be supplied with carbonic acid from decomposition, and so the mud be saturated with a weak solution of phosphate of lime. Now, if at a certain point in the mud there were an excess of phosphate of lime, and especially if ammonia were being evolved at that point, the phosphate in the neighboring solution might be precipitated; and probably (for it seems to have often happened with other minerals) all the phosphates of the surrounding mass would be precipitated about the nucleus. I regard, then, these nodules as the result of a process which took place during a part of the Gault period, and was continued during the Greensand epoch, which began shortly after the death of the organism, and lasted for a long time; and I explain their abundance, as I have already said, by considering the seam as the riddlings of a considerable deposit. It is noteworthy how often a bed of phosphate nodules comes just above a more or less marked stratigraphical break. It appears to me, therefore, that the process of formation of these nodules is . . . very analogous to that of flint; both, in many cases, proceeded from the mineralization of sponges."

"It may not unfairly be asked, why, seeing that weak solutions of phosphate of lime must be almost always present in sea-water, are not phosphate nodules generally present in rocks. The answer to this is that phosphate nodules are far from rare, and that the difficulty is exactly of the same kind as exists in the formation of flint."

"It may be that local circumstances, as indicated above, have been favorable to slightly concentrating the phosphatic element in the sea-water; but without availing ourselves of this possibility we may fairly answer that the process of deposition from weak solutions, one of which we are very ignorant, is probably a complex process which requires several independent conditions to be fulfilled, so that it is but rarely that all are satisfied."

I have spoken above of the circumstances that casts of fossils are generally phosphatized, while those fossils, especially those of the oyster family, which retain their original shells, show scarcely a trace of phosphoric acid.

The purer limestones also, (i. e., those containing least clayey matters,) are usually very slightly, if at all, phosphatic. This circumstance is accounted for by Mr. Keeping (Fossils of Upware) on the supposition that the purer carbonate of lime was uncongenial to the phosphate matter which was taken up more readily by the more argillaceous mud, which formed the impure limestones and which filled the cavities of the shells and produced the casts and moulds of which we have spoken.

The lesson to be learned from a careful study of the mode of occurrence of our phosphates, and of the conditions under which they have probably been accumulated, are obvious. We see that the formation of phosphatic deposits is not confined to any one geological period, but will follow whenever certain conditions, (some of which have been given above) are fulfilled. The association of phosphatic deposits with breaks or interruptions in the conformability of the strata, and the connection between the two, are also not without their practical bearings.

CALCAREOUS MARLS (NOT PHOSPHATIC) OF THE CRETACEOUS AND TERTIARY FORMATIONS.

For the sake of completeness we append here a short notice of certain calcareous marls, which have no unusually high percentage of phosphoric acid, but which can be advantageously used in agriculture where they are easily accessible.

Cretaceous marls.—In the upper part of the Eutaw formation, throughout the Rotten Limestone, and in the overlying Ripley, there are beds of calcareous matters which may be profitably used upon the fields where the cost of applying them is not too great. Most of these marls have been spoken of in connection with the phosphatic marls with which they are commonly associated, and there appears to be little need of adding to what has already been said.

Tertiary marls.—The principal horizon at which these materials occur are:

(a) In the Nanafalia section of the Lignitic, already mentioned in connection with the phosphatic marl. This marl bed appears in the bluffs of the Tombigbee river at Nanafalia Landing in Marengo, and thence for several miles down to Gay's Landing; on the Alabama it appears at Black's and Gullette's Bluffs and a short way up the river from the latter place. Between the two rivers this bed crosses Marengo and Wilcox counties, and thence it may be followed eastward to the Chattahoochee river at Fort Gaines. This bed is prevalently a sandy bed with much greensand, loose shells, and occasional ledges with an excess of phosphate. It crops out at the foot of the Grampian Hills in many places. It is one of the most widely distributed and uniform of the marl beds of the state.

An analysis has been given (p. 497, No. 170), of a phosphatic ledge of this marl bed at Nanafalia, and I append here another analysis showing the general character of the formation. No. 175 (p. 507) was taken from the Nanafalia Bluff. Whenever this marl occurs its presence is easily recognized by the vigorous growth of the shrubs and herbs. Its fertilizing action is everywhere naturally demonstrated.

(b) The Wood's Bluff or Bashi marl has been mentioned incidentally above. This marl occurs in its typical exposure at Wood's Bluff on the Tombigbee river. It is seen at the base of the Buhrstone hills in Choctaw county, in the town of Butler, near Pushmataha and in other places. Between the rivers it is seen along Bashi creek, near Choctaw Corner, below Lower Peach Tree, and at the Alabama river at Johnson's Island. Across the Alabama it appears in the lime lands below Bell's Landing, along the lower prong of Flat creek, whose soils are made by it exceptionally fertile, thence into Butler by Sepulga, and Georgiana, across the lower end of Crenshaw into Coffee, appearing at Kimmey's Mill below Elba. Thence it may be followed to the Chattahoochee river, which it reaches about Zornville. But east of Coffee county, superficial sands cover the older rocks to such an extent that their only exposures are to be seen in the ravines and in the banks of creeks, etc. This marl, like the preceding, contains a large percentage of greensand, as well as of decomposed shells, which furnish carbonate of lime in very available form, almost pulverulent. There is no single marl in the state that is in better condition for use upon the fields than the Wood's Bluff marl.

Many years ago Prof. Tuomey induced Mr. Kilpatrick, at Wood's Bluff, to use this marl upon his garden, and his sons have told me that the effects of its use were plainly discernible for many years. One need, however, only notice the vegetation along the line of outcrop of this marl bed to be

assured that it is a good fertilizer. The lime hills just below Bell's Landing, and the lowlands of Flat creek in Monroe, may be cited in confirmation of this statement. I give on page 507 two analyses of this marl, No. 176, taken from near Butler, in Choctaw county; the other, No. 177, from "the caves" near Choctaw Corner in Clarke county. At this last named place, as well as at Wood's Bluff, the marl is most conveniently situated for digging, and there is no reason why it should not be extensively used.

(c) In the Claiborne section there is no lack of good shell marls.

At the Claiborne Bluff itself the main shell bed of 17 feet in thickness was originally a greensand bed, but where this bed lies exposed to the weather it becomes oxidized and assumes a red or yellowish color. This bed, though packed with shells, has the interstices filled in with sand, and thus the percentage of silica runs up pretty high. Its value as a fertilizer depends solely upon the carbonate of lime of the shells, which is usually in not so available condition as in the case of the Wood's Bluff marl. Analysis No. 178 shows the composition of this bed at Claiborne. Below this stratum follow many feet of calcareous beds, some of which contain large amounts of lime and are suitable for use as marls. No. 179 shows the character of these beds at the Claiborne Bluff, and No. 180 their characters at the Coffeeville Landing on the Tombigbee. (Analyses on page 507.)

Where this bed outcrops in the piney woods of Clarke and Choctaw, it causes the formation of what are locally called "piney woods prairies," i. e., limy fertile spots in the piney woods, a testimonial to the fertilizing qualities of the marl. At no place is this marl more easy of access than at the Coffeeville Landing.

(d) The White Limestone, as its name implies, is a calcareous formation. The lower part of this formation has generally the composition of an indurated marl similar to

the Rotten Limestone of the Cretaceous. In its disintegration it yields a soil similar to that of the latter. These soils characterize the Lime Hills of Clarke, Washington, Choctaw, Monroe, etc. No. 181 shows the composition of this rock as it occurs in the upper part of the Claiborne bluff in Monroe county.

The upper part of the White Limestone formation contains a large amount of a soft chalky limestone that could easily be pulverized and rendered fit for application to the fields which it would undoubtedly, in almost every case, greatly benefit. This formation crosses the entire state and underlies the whole peninsula of Florida. It is easily dug up and cut when fresh, and for this reason is much used in the construction of chimneys, underpinning for houses, etc. Its composition is fairly well shown in analysis No. 182 (page 507), of a specimen taken in Clarke county a short distance north of Jackson.

Table of Analyses of Marls and Greensands, (not highly phosphatic) from the Tertiary Formations of Alabama.

NAME AND LOCALITY.	Insoluble Matter.	Carbonate of Lime.	Potash	Phosphoric Acid.	ANALYST.
a. Nanafalia Section.					
175. Greensand marl, Nanafalia Land'g, Marengo county.	37.38	43.15	2.25	.04	H. McCalley.
b. Wood's Bluff Section					
176. Greensand shell marl, near Butler, Choctaw county..	67.84	24.74	1.03	.16	"
177. Greensand shell marl, Choctaw Corner, Clarke county.	64.44	31.02	.46	.22	"
b. Claiborne Section.					
178. Shell marl, Claiborne Bluff, Monroe County.....	47.86	47.07	.33	.03	"
179. Greensand shell marl, Claiborne Bluff, Monroe county,	62 31	27.20	.63	.13	"
180. Greensand shell marl, Coffeeville Landing, Clarke co.	64.31	26.85	.37	.04	"
d. White Limestone Section.					
181. Soft white limestone, Claiborne Bluff, Clarke county.	31.31	62.42	.50	.09	"
182. Soft white limestone, near Jackson Clarke county....	2.54	86.78	.35	.31	T. W Palmer.

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factures of superphosphate, unless ground to fine powder —"floats." They are equal to the Charleston phosphates in their percentage of phosphoric acid and in the absence of any large percentage of iron and alumina.

The experiments of Prof. Stubbs, made upon a number of samples of these nodules, and described in the Bulletin No. 5, of the State Agricultural Department, have shown that acid phosphates of good grade can be made out of the nodules, so that the only question of importance relates to their abundance.

In the vicinity of Hamburg and at some other localities these nodules lie loose upon the surface in large quantity, and probably represent the *debris* from the wearing away of the containing rocks during many ages, for in the matrix or containing rock of these nodules at Hamburg, the nodules were not found in place in sufficient quantity to be of importance. Similarly with regard to the phosphatized shell casts from this lowermost of the phosphate beds; they do not appear to be abundant enough to supply a manufactory of acid phosphate.

Again, just above the Rotten Limestone, we find similar shell casts which have the composition of the phosphatic nodules, and which, if abundant enough, could be used in the manufacture of superphosphate.

Lastly, in the uppermost beds of the Cretaceous formation, interstratified with yellow and gray sands, we find in the northern part of Marengo and Wilcox counties, very considerable beds compactly filled with these phosphatic casts, an average of which shows over 20 per cent. of phosphoric acid. These casts are much softer and more easily reduced to powder than those occurring at lower horizons in the Cretaceous formation, they could be used in the manufacture of acid phosphate, and they appear, so far as examinations have gone, to be in sufficient quantity. At a few localities certainly, they make almost compact beds several feet in thickness, and a further investigation is much to be desired, and promises well.

b. The greensands.—Under this head we shall consider both classes of greensand, viz: Those with very little carbonate of lime, and those containing 15 to 20 per cent. and above of it.

Among the strata which immediately underlie the Rotten Limestone, and which crop out across the state in the belt which includes Eutaw, Hamburg, Wetumpka, etc., there is the highly phosphatic greensand already described in detail, and exhibited by many analyses. This bed is perhaps on an average, five feet in thickness, and certainly in the counties of Perry, Dallas and Autauga, and probably in the others also, is rich enough in phosphoric acid to be advantageously used upon the soil. It may be used alone, or better with vegetable matter of some sort. Prof. Stubbs, in the Bulletin above referred to, gives the following recommendations: "These sands can be used in large quantities without fear of injury, but it is best always that they be applied either upon soils rich in humus, or in connection with vegetable matter. Composted with stable manure and cotton seed, and the mixture covered with a thin layer of gypsum or thick layer of rich earth and permitted to remain for several months, is perhaps the best way to utilize them. In making such compost, large quantities of greensand must be used. I would recommend the following proportions:

100 bushels of stable manure,
10 bushels of cotton seed,
100 bushels of greensand,

put up in the way and manner described for making composts in a former bulletin. This compost should remain up much longer than one prepared with acid phosphate—in fact, the longer the better—even twelve months would not be too long, provided the compost had been properly made, and under shelter."

The recommendations would apply also to the calcareous greensands which occur just above the Rotten Limestone and which contain a smaller percentage of phosphoric acid, but a much larger percentage of lime. These last named

marls have been actually tested in the field, and the result yielded have been of such a nature as to encourage the experimenter to continue the use of them on a much larger scale.

This upper bed has an average thickness of three feet, and it is known to extend from Coatopa, in Sumter county, past Snow Hill, in Wilcox, to near Bragg's Store, in Lowndes, having essentially similar composition throughout this distance.

In regard to quantity therefore, these two beds are sufficiently large to be profitably worked.

2. *Comparison in Detail of the New Jersey Phosphatic Marls, with those of Alabama.*

We have said above that the Greensands of Alabama have essentially the same composition as those of New Jersey, which are so highly prized and universally used in that state, and our assertion was based upon a comparison of the published analyses of the New Jersey marls with those recently made from Alabama materials. Not to go too much into details, I have here taken the mean of a great number of analyses of the Alabama greensands, and placed them in comparison with the average from analyses of the New Jersey marls. And since the experience of farmers has shown that the marls are valuable first of all, in proportion to the percentage of phosphoric acid which they contain, I have made the comparison on the basis of this ingredient, calling attention where needed, to the percentage of carbonate of lime, which experience has also shown to be a very valuable constituent of all the marls.

A. New Jersey Marls.

1. The average marl from the lower bed (New Jersey) contains 1.14 per cent. phosphoric acid, which is not high, but the marl contains in addition, 10 to 20 per cent. of carbonate of lime, in fine powder. "In the neighborhood of the marls where it costs but little more than the cartage, a

great deal is used which is much poorer than this, but there is no trouble in finding millions of tons of this quantity. It is used in larger quantity than the other varieties, and is remarkable for the permanent improvement it makes in the soil." (Extract from Report of State Geologist of N. J.)

The average of five analyses given as representing the green marls of the Middle Bed, shows about 2 per cent. of phosphoric acid. Many hundred tons of this marl are shipped every day over the railroads to the different parts of the state.

3. The average of four analyses given as representing the composition of marls of the Upper Bed, shows about 3 per cent. of phosphoric acid. This marl is also shipped by rail to all parts of the state.

These averages are considered by the State Department of Agriculture of New Jersey, as showing the general character of the three grades of marl in use in this state.

For the sake of comparison, I have taken the means of a number of analyses of typical samples of the various marls occurring in Alabama, showing the average percentage of that most important constituent, phosphoric acid.

B. Alabama Marls.

The Hamburg Greensand.

The line of outcrop of this belt across the state, near Pleasant Ridge, Eutaw, Marion, Hamburg, Selma, Mulberry, Prattville, and Wetumpka, has already been given.

The locality at Hamburg has been much more closely examined than any other in the state, and a great number of specimens from there have been analyzed.

The greensand proper is about five or six feet in thickness, but associated with it is a bed of about the same thickness, which holds phosphatic nodules, and which itself is highly phosphatic. We shall call this the Matrix of the nodules to distinguish it from the greensand.

(a). *The Greensand.* This varies very considerably in composition as may be seen from the analyses already given.

Excluding all the exceptionally high percentages, we find as the mean of eight analyses of the average typical greensand, 4.6 per cent. of phosphoric acid. The whole bed will in all probability sustain this average.

(b). *The Matrix.*—The analyses of eleven typical specimens give an average of 2.5 per cent. of the phosphoric acid.

Specimens from this bed have been collected and analyzed from Marion, Greensboro, Choctaw Bluff, Eutaw, Selma, Summerfield, and localities in Autauga and Elmore counties but no care was taken in selecting the sample, to separate the greensand from the matrix of the nodules, and the following analyses may be considered as representing the averages of the two combined.

The average of four analyses of specimens from Marion, show 2.9 per cent. of phosphoric acid; of three specimens from Eutaw to Greensboro, 4.2; of four specimens from between Selma and Summerfield, 4.46; of seven specimens from Autauga county between Mulberry and Prattville, 3.15; of three specimens from near Wetumpka, 1.15 of phosphoric acid. The average of these nineteen analyses, together with the twenty-one from Hamburg, forty in all, thus given as fairly showing the composition of the greensand at the different localities between Eutaw and Wetumpka, shows 3.33 per cent. of phosphoric acid, and I am satisfied that the bed will sustain this average, or even show a higher percentage when a greater number of analyses is made.

The Livingston, Coatopa, Richmond, Fort Deposit Greensand.

This bed, as has already been said, comes to the surface in a belt approximately parallel to the preceding, but on the southern border of the prairie region. Associated with it are the phosphatized shell casts, and the silicious phosphatic limestone which have been mentioned above.

The greensand has been examined at several points extending from Coatopa, in Sumter county, to Snow Hill, in Wilcox county, and it has pretty uniform characters through this whole distance. Its thickness is some four or five feet, and like one of the New Jersey marls above described, holds in addition to the phosphoric acid, about 50 per cent. of carbonate of lime in a fine earthy powder.

The average of eight analyses of this greensand from various localities from Coatopa to Snow Hill, shows 1.44 per cent. of phosphoric acid, and over 30 per cent. of soft pulverulent carbonate of lime. The close approximation in composition of this greensand to some of the New Jersey marls which have been so successfuly used, would be a good recommendation of itself, but we have fortunately a few field experiments which have tested its value in a practical way. (These experiments are described below.)

While this marl contains much less phosphoric acid than the marl of the Hamburg belt, it will doubtless prove an efficient fertilizer by reason of the carbonate of lime which it holds in addition to the phosphoric acid.

The Nanafalia Marl.

In addition to the two great marl beds above described, of the Cretaceous formation, attention has recently been called to others in the Tertiary formation to the southward.

The most important of these, and one of the most important in the whole state, is the Nanafalia Marl, which appears on the Tombigbee river at Nanafalia Landing, Eureka Landing, etc., and on the Alabama at Black's and Gullette's Bluffs, but which may easily be traced across Choctaw, Marengo and Wilcox counties into Butler, and thence to the Chattahoochee river. This is a greensand marl, rich in carbonate of lime, and having a very considerable thickness, in places of thirty to fifty feet, but the main bed is from fifteen to twenty feet. Some of the indurated ledges which traverse this marl bed, hold as much as 6.7 per cent. of phosphoric acid, but the average will fall much below this, so

that it might perhaps not be classed with the phosphatic marls at all; still, the physical condition of the marl, and its high per cent. of carbonate of lime, will make it one of the most valuable natural fertilizers in the state.

The analyses made, show from 40 to 70 per cent. of carbonate of lime.

The Wood's Bluff or Bashi Marl.

This bed of green sand with high per centage of carbonate of lime, appears at Wood's Bluff on the Tombigbee river, and at Johnson's Wood Yard, just below Bell's Landing on the Alabama river, and in many places in the interior of Choctaw, Clarke and Monroe counties. It has comparatively little phosphoric acid, but a large amount of carbonate of lime, and is usually in most excellent condition physically, being almost pulverulent, especially where protected by the indurated portions of the bed. Some tests have been made of it as a fertilizer in Clarke county, and the results have been very satisfactory.

The St. Stephens Marl.

Lastly, at St. Stephens on the Tombigbee river and extending across Choctaw, Washington, Clarke and Monroe counties, there is a clayey marl which appears as the basis of the "Lime Hills" soils which exhibit an exceptional degree of fertility. I have not heard of this marl being used as a fertilizer, but there is no doubt of its effect upon the light and sandy lands which are found always close to it.

3.—Can our Phosphatic Marls be Profitably Used?

We have seen above that our marl beds extend over a great area and contain each a quantity of available marl sufficient for all our needs for many generations to come. As regards their quality we have seen that they are very similar to the marls so extensively used in New Jersey.

The question that now most concerns us is whether or not these marls can be profitably used upon our soils. I

think this question can be affirmatively answered. 1st. Upon general scientific principles. 2nd. By noting the results attained by the farmers of other states, notably New Jersey, by the use of marls quite similar in quality to ours. 3rd. By giving the experience of the few among the farmers of our own state who have used these very marls upon their fields for the past five or six years.

1st. Objection has been urged even by chemists that so small percentage of phosphoric acid, and that too in the insoluble form, can be of comparatively little benefit to the growing crop. In answer to this objection it may be said that the experience of New Jersey farmers, and of our own, too, so far as it goes, has demonstrated beyond all peradventure, that marls with this small percentage of phosphoric acid and in this insoluble form *do actually* prove of benefit to crops and *have actually* brought the New Jersey soils from the condition of barren sands up to a degree of fertility which is not equalled by the soils of any other state of the Union.

It seems to me that this should be conclusive, but as I have time and again published these facts, and there still remains doubt as to the value of our phosphatic marls, perhaps an attempt to show *how* it happens may not be out of place.

Commercial phosphates are, as a rule, applied to the soil in a soluble form, but experiments by Thenard have shown that when given to the soil in this form the phosphoric acid very speedily (after the lapse of a day or two at most), goes into insoluble combinations with the iron, alumina, lime, or magnesia of the soil, and since the plant contains a very small percentage either of iron or alumina or lime or magnesia, it is certain that the phosphoric acid is not assimilated from these insoluble compounds until they are decomposed, and this decomposition appears, for the most part, to be effected through the agency of the alkaline salts present in the soil, and partly, also, as shown by the experiments and observations of Liebig, Heiden, Knop, and others, through

the solvent action of the acid excretions of the plant roots themselves. The experiments show that the phosphoric acid of commercial super-phosphates, after two or three days, contact with the soil, is in quite as insoluble a form as the phosphoric acid of our marls. If the plant is able to assimilate the phosphoric acid from the first, it is certainly possible for it to do so from the second.

In the notice of Alabama phosphates in the report on the Mineral Resources of the United States for 1886, Dr. Day writes as follows: "Since the announcement of the discovery of the phosphates in 1884, it is remarkable that very little has been done towards utilizing these deposits. The chief reason for this seems to be the reluctancy to invest capital in an industry which can only turn out a product to be consumed locally. These phosphates and marls are, however, extremely valuable and there is absolutely no reason why they should not be used in much larger quantities than in the prosperous state of New Jersey, where of marls alone at least 800,000 tons by no means so rich in phosphoric acid, are annually applied to the soil. The questionable opinion seems to be prevalent that only such fertilizers can be used to advantage, in which the phosphoric acid is in a soluble condition. It is true that for quick benefit, such fertilizers give most immediate returns, but the employment of ground bones shows the benefit which can be obtained from the use of fertilizers in which the phosporic acid is insoluble. In the phosphate rock of Alabama, the percentage of phosphoric acid is lower than in ordinary commercial fertilizers, and it is less soluble, but still the poorest of these marls contains many times the phosphoric acid of an ordinary rich soil. Therefore the question of utimate benefit is simply as to how many tons of marl or phosphate must be applied per acre, to add to the soil as much phosphoric acid as is contained in the quantity of commercial fertilizers ordinarily applied. A serious difficulty in selling the phosphates and marls is offered by the state laws, which rule out of the market the only mineral substance which this state possesses."

2nd. I am aware that with many, and very naturally too, an opinion based upon general considerations has very little weight, and I therefore present the following from the experience of the New Jersey farmers in the use of materials similar to ours.

The greensands of New Jersey have essentially the same composition as ours, as has been shown at length in division 2 above, and here are some statements taken from a Report of the New Jersey Board of Agriculture, showing what a complete revolution the use of these marls has worked in that state. "The marl has been of incalculable value to the country in which it is found. It has raised it from the lowest stage of agricultural exhaustion to a high state of improvement. Found in places where no capital and but very little labor were needed to get it, the poorest have been able to avail themselves of its benefits. Lands, which in the old style of cultivation had to lie fallow, by the use of marl produce heavy crops of clover and grow rich while resting. Thousands of acres of land which had been worn out and left in common, are now, by the use of this fertilizer, yielding crops of the finest quality. Instances are pointed out everywhere in the marl district of farms which in former times would not support a family, but are now making their owners rich from their productiveness. Bare sands, by the application of marl, are made to grow clover and then crops of corn, potatoes and wheat. What were supposed to be pine-barrens, by the use of marl, are made into frutiful lands. The price of land in this region was considerably below that in the northern part of the state forty years ago; now that the lands are improved, theis prices are higher than those in the northern part of the state, though even there they are higher than anywhere else in the United States."

In the winter of 1876-7, a series of questions relating to the quantity of marl used per acre, the benefits resulting from this use, the mode of application, etc., was sent out to the farmers of New Jersey, and from the answers received, detailing the results of experience, together with the chemi-

cal analyses of the marls, the following conclusions were drawn:

"1st. That the most valuable marls and those which will pay best the cost of long transportation, are those which contain the highest percentage of phosphoric acid.

"2nd. That the most durable marls are those containing carbonate of lime, the more the better.

"3rd. That the potash in the marl has but very little, if any, present value, it being combined with silica, and so insoluble.

"4th. That greensands containing but little of either phosphoric acid or carbonate of lime, became active fertilizers when composted with quick lime.

"5th. That marls which are acid and burning from containing sulphate of iron, can be rendered mild in properties and useful as fertilizers by composting with lime.

"7th. That crops particularly improved by it are all forage crops—grass, clover, etc.; for these the green marl may be spread upon the surface to the amount of from one hundred to four hundred bushels per acre. The crop is generally doubled, and in some cases quadrupled, by the application. Other marls must be used in larger quantities, but will produce good results."

3rd. With this statement of the chemical and physical characters of our Alabama phosphatic marls, and with the record of the experience of New Jersey farmers in the use of similar marls, which to say the least are no better than ours, (and all the analyses show them to be if anything inferior) can any one doubt that our marls, if properly used, will be of inestimable benefit to our farmers?

But we are, fortunately, not obliged to go out of the state for data to show that our marls are of value.

Since their discovery in 1884, four farmers residing in different parts of the state, have been induced to make thorough tests of them, and since these tests have been made with all the varieties of phosphatic marl above mentioned, and upon every variety of soil and in four widely distant localities, I

think they may be taken as giving absolute practical proof of what we may expect from the use of these marls.

The greensands of the Hamburg belt have been tried at Eutaw by Mr. T. J. Anderson, the Coatopa marl by Mr. John Wiatt at Coatopa, by Dr. G. W. Kyser at Richmond, Dallas county, and the Nanafalia marls by Capt. W. H. Homer of Mobile.

Mr. Anderson writes, (1886): "Last year my son and myself experimented somewhat with the marl and with good results. You remember the old field near the bed of marl was poor and worn out. It took an average of five acres to the bale of cotton. On one acre we put nothing but the marl, pulverized as well as we could do it with a good corn and cob crusher. We used about three-quarters of a ton on that acre, and no other fertilizer. The result was 1,200 lbs. seeds cotton. On another acre we used the same amount of marl and 30 bushels of crushed cotton seed; result about the same. On another acre we used marl, stable manure, and lot scrapings with about the same result. To the poorest spot (about three acres) we then applied the marl mixed with coal and pine wood ashes; result about 600 lbs. seed cotton to the acre. We noticed that the marl did best on clay land, and that where it was used alone and freely, the long dry spell did not show its effect much."

"We planted some cotton in an old road, nothing but clay, using the marl freely, and the stalks never did shed the foliage until frost. We are perfectfully satisfied with the results and intend to use the marl more extensively this year. We also used it on Irish potatoes with fine results both as to quantity and quality. Also tried it on the sweet potatoes, but the result was unsatisfactory, more vines than 'taters.'"

I may remark in connection with this extract that the material used by Mr. Anderson is not the greensand proper, with its high per cent. of phosphoric acid, but has rather the composition of the matrix of the nodules, say one or two per cent. The Hamburg greensand itself has never, to my knowledge, been adequately tested.

Mr. John Wiatt of Coatopa, writes (1886): "In reply to your inquiry I will say that my experiments with the marl have been very satisfactory. You will remember that when you were here last, you suggested that I make an experiment with the clay marl alone by spreading it broadcast upon the land. I did this last year, on half an acre, applying at the rate of eight tons to the acre. Adjoining this on the same quality of land I used compost, about the same quantity and with but little better result than from the marl alone. I think where nothing but the marl was used, the dry weather affected the land less than where the compost was used. I notice that the lands where the marl has been applied for the last three years in small quantities in compost, are changing very much in color, growing darker and where formerly it baked badly, thus preventing a stand of cotton, it is now entirely changed, having become soft and mellow, and therefore more productive. The result from the ground rock is much more marked."

In addition to this report from Mr. Wiatt I may say that when I visited his place two years ago, there were several spots in his field conspicuous by the deep green color of the foliage of the cotton plants, and the greater height of the stalks, nearly twice that of the plants in the rest of the field. On enquiry I was told that these were the spots where he had first thrown the marl in piles from which it was afterwards distributed over the rest of the field. In spreading the marl, the rest of the land received a good deal less than was left on these spots. There could hardly be given a clearer indication that the marl had been too sparingly used over the rest of the field, for the marl had not been left long enough in these piles to have brought about any such result by the shading of the soil beneath. I am glad to say that Mr. Wiatt took the hint and more than doubled the quantity of marl upon his field the next year.

Mr. W. S. Purifoy of Snow Hill, was one of the first to make use of the marl, which, fortunately, was found very convenient of access upon his land. He has experimented

with it every year since 1884, and has published at my request, the results of these trials each year. At this time, 1886, he writes: "There is one result attending the use of the marl of which I have not yet made mention, and that is that it improves the physical condition of aluminous soils, rendering them more easily cultivated; the loose nature induced by their application favors the germination of the seed, thereby securing a stand more readily. This condition of the soil is also favorable to the growth of the crop, in that it permits access of the atmospheric air and brings about the conditions necessary to reduce the elements of the fertilizer to the form in which they are best suited to be taken up by the plants. To bring about these physical conditions, is in my opinion, no less important than to supply the elements of plant food. I have been using these marls on my lands with satisfactory results each year since their discovery. I apply it in connection with cotton seed and stable manure. Lands that had been exhausted and given up to sedge and briars are now producing paying crops. Experience has shown the economy of bringing up lands gradually; which fact has induced me to pursue such methods as will render the land perceptibly more productive for each succeeding crop. To this end I have increased the proportion of marl in my compost heaps relatively to the other ingredients. The proportions as now used are as follows: Marl 1,500 lbs.; stable manure, 300 lbs.; cotton seed, 200 lbs.; making one ton, which I apply to an acre. With the lights now before me, I shall follow this plan in the future."

Mr. Purifoy's experiments, extending over a number of years, go to show that while the plants grow off more rapidly when fertilized with superphosphates, they stand the later drouths better and produce finally as good crops when treated with the phophatic greensands.

Quite similar to Mr. Purifoy's is the experience of Dr. Geo. W. Kyser, of Richmond, Dallas, Co., also extending over a number of years. He has used as fertilizers not only the greensand marl, but also a ground up phosphatic rock

occurring on his place. Dr. Kyser made some comparative tests which are of interest. The commercial phosphates caused the cotton plants experimented with to grow off much faster than the ground rock and greensand, but on the other hand, those plants fertilized with the rock and greensand stood the drouth much better and were green and flourishing at least three weeks after those treated with the commercial fertilizer had turned red and ceased making.

I have no report direct from Capt. Homer, but Mr. D. W. Langdom, Jr., informs me that he has for some years been using the Nanafalia marl, with great profit to himself, upon his market gardens in Mobile.

4. *Limitations to the Use of the Marls Depending upon their Cost.*

Even where a marl is known to exert a good effect upon the growing crop, the cost of getting it up and applying to the lands, might easily be greater than the benefits resulting from its use, and this is particularly likely to be the case where the marl is at a distance from the crop, and has to be transported by rail or wagon. There is in all these marls a very considerable percentage of inert matter, which very materially increases the cost of transportation.

We may make a rough approximation of the value of the phosphatic marls by assuming that the phosphoric acid is the only effective ingredient, and basing our calculations upon that assumption; if in addition, the marls contain a notable quantity of carbonate of lime, so much the better.

Available phosphoric acid is estimated now to be worth about 7.5 cents a pound, and we shall certainly be on the safe side if we put the value of the phosphoric acid of our marls at 5 cents a pound. With this valuation a marl with 1 per cent. of phosphoric acid would contain 20 lbs. to the ton, and be worth $1.00 a ton. A marl containing 2 per cent. would be worth $2.00, and so on.

With these data it might be easily calculated whether or not it would pay to apply a marl to the land. It would ob-

viously not pay to transport any of the Alabama marls long distances by rail, with the present high rates of freight; but if experience should show that these marls were better than many of the commercial phosphates, the freight rates would certainly be reduced when the amount of traffic would justify it.

In looking over the Reports of the New Jersey farmers upon the cost of the marls in that state, we find that it varies from 40 or 50 cents a ton in the immediate vicinity of the pits, to $2.50 where it has to be hauled, say 10 miles. The farmers find that it pays even at the last named price, including all the cost of transportation, spreading, etc.

As to the value of the greensands as compared with stable manure, the New Jersey farmers vary in their experience. Some consider it equal to the barn-yard manure, load for load; some consider it better for certain crops, especially for grass; while others think one load of barn-yard manure equal to two, or even in a few cases, to three of the greensand.

We shall certainly not be overestimating its value when we consider our greensand to be worth about half as much per ton or load, as stable manure, and upon this assumption it will be easy for any person to determine for himself, whether or not it will be profitable for him to use greensand. All the above estimates refer to the immediate results to be gotten from the use of marls, but it should be borne in mind that the phosphatic greensands produce a lasting improvement of the lands upon which they are used, and the good effects of their use can often be seen for years after they have been applied to the soil. This should have some weight in estimating their value.

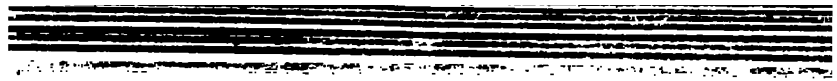
In the application of our marls, I do not think we can do better than to follow the practice of the New Jersey farmers, who use their marl either alone, spreading it upon the land in the fall and winter months, in quantity varying from 10 to 50 tons per acre, the more the better. In this form it answers well for clover, grass and other forage plants. Or they compost it with equal parts of stable manure, or

with stable manure and quicklime, in which form it is a good fertilizer for all crops without exception.

It is sometimes urged as an objection to the use of the marls that our farmers need quick results and cannot afford to build up their lands for the benefit of posterity alone.

That this objection is absolutely without weight has been conclusively shown by the experiments of Mr. Purifoy, in which it was seen that while the crops fertilized with acid phosphate grow off a little more promptly *at the beginning* of the season, those upon which the marl was used in proper quantity quite equalled the first *by the end* of the season, so that even upon the first crop the marl proves of as much benefit as the commercial fertilizer, and there can be no comparison between the two as regards the permanent improvement of the soil.

Those farmers throughout the state upon whose lands these marls occur, could not possibly be losers by giving the marls a thorough test in the field, on the contrary they could hardly fail to be gainers thereby. It is to them that we must look for the introduction of the marls into the agricultural practice of Alabama.



PART III.

GEOLOGICAL DESCRIPTIONS OF THE COUNTIES OF THE COASTAL PLAIN OF ALABAMA.

—BY—

Eugene A. Smith.

COUNTY DESCRIPTIONS.

The county descriptions which follow, present in connected form the main geological, topographical, and agricultural features of each of the counties embraced in this section of the state, and contain generally, matter not appearing in the other parts of the Report. Of the counties which fall partly or wholly within the limits of the Coastal Plain, there are nine in which only the Tuscaloosa strata of the Coastal Plain formations appears, and since all the details of this formation in these counties, are given in the general discussion of the Tuscaloosa group, a repetition of them in the form of county descriptions was not thought desirable. The counties referred to are Lauderdale, Colbert, Franklin, Marion, Lamar, Fayette, Tuscaloosa, Bibb, and Chilton. And moreover since these counties are in part formed of the strata of the older geological formations, additional details concerning their geology will be found in the Reports on the Mineral Regions.

The counties are taken up in general in the order of the geological formations beginning with the oldest, but it has been impossible as will be seen by a moment's reflection, to follow this plan consistently in every case.

PICKENS COUNTY.

The underlying Cretaceous formations of Pickens are the Tuscaloosa, the Eutaw and the Rotten Limestone. The former occupies the northeastern, and the second the southwestern half of the county lying east of the river, while the last named occupies the small area west of the river. The territory of the *Tuscaloosa* is much broken by reason of the

clays and sands of which it is composed, and the readiness with which they are removed by erosion. The roughness of the topography is specially felt in going *across* the country, i. e. across the general direction of the streams and watercourses. Where these watercourses are far enough apart the divides between them are of the nature of high level plateaus with red loam soil underlaid by pebbles, of the Lafayette formation which was once universally present. Below this mantle of loam and pebbles the cross-bedded sands and massive clays of the Tuscaloosa are exposed. This whole region in Pickens is of the general nature of the oak and hickory uplands with short leaf pine. Where the sands prevail in the soils the blackjack, and turkey, and upland willow oaks form the growth, but with the better class of loam soils these oaks are in great measure replaced by red, black, Spanish and post oaks, and the proportion of the pine diminishes.

The territory of the *Eutaw* is also a region of broken topography but the soils are as a rule more productive, and especially towards the southwestern border where the greensands and calcareous strata become more prevalent, forming a transition to the small tract of prairie lands in the extreme southwestern corner of the county. Fine plateaus, with the fertile brown loam soils of the Lafayette, lie between the main streams, as for instance below Carrollton between Lubbub and Blubber creeks, about Franconia, and elsewhere.

The small area occupied by the *Rotten Limestone* in Pickens, on the southwestern side of the river, includes some of the most beautiful farming lands and most attractive country in Alabama, as may be seen between Sherman and Fairfield (Stone P. O.). A little of the Rotten Limestone laps over the Eutaw on the other side of the river, but it has in great measure been carried away and its place is now occupied mostly by the sands of the river. The river bluff at Fairfield gives a fine section of the lower strata of the Rotten

Limestone, which is at this place quite fossiliferous, the most striking feature being the great number and size of the shells of a species of *Inoceramus*, some of which are more than a foot in diameter. On account of the fibrous nature of these shells they are so easily broken as to make it impossible to get any of them unbroken out of the rock.

GREENE COUNTY.

A small area, about a township more or less in the northeastern corner of Greene, is based upon the *Tuscaloosa* beds, well seen along the road about Knoxville, where in Mr. Patton's field we have the following section:

Section of Tuscaloosa Strata, near Knoxville.

1. Red loam.....10 feet.
2. Yellowish cross-bedded sands.....15 feet.
3. Yellow and pink sands with pebbles of white, gray and red clay, 10 feet.

The pink sands above mentioned are very similar to those seen in the gullies below Havana on the other side of the river, and occupy approximately the same horizon, which is near the summit of the Tuscaloosa. From Knoxville down to Steele's Bluff, we pass over cross-bedded sands with thin flakes of gray clay along the planes of false bedding. In these reddish sands there are many silicified tree trunks, which appear to belong either to the lowermost of the Eutaw sands or to the uppermost of the Tuscaloosa. In many places near Steele's the appearance of the stratified sands suggests that the lower Eutaw beds are the worked over and redeposited materials of the Tuscaloosa. At Steele's we get the following:

Section at Steele's Bluff.

1. Second Bottom deposits.....5 feet.
2. Purple and gray massive clays, becoming more and more sandy in the lower parts. This power part consists in the main of sands

with enough clay to make a plastic mass; colors variegated and mottled..... ..... 15 feet.

3. White and yellow sands, splotched with purple, and with strong tendency to induration on surface..... .... 6 feet.

The purple clays (2) are also seen along the road coming up the hill at an altitude fifty or sixty feet above the water level.

From Knoxville on to Eutaw the road is over the *Eutaw* sands alone. The lower strata of this formation consist of yellow and red cross-bedded sands with thin sheets and flakes of gray clay parting the sand layers. Further south, or within eight miles of Eutaw, dark gray laminated clays, alternating with yellowish sands, become more and more prominent. These clay partings break up into small pieces. Near Eutaw the clays are overlaid by some 20 to 30 feet in places, of cross-bedded greensands. From these the resulting soil is a deep red colored sandy loam, somewhat like the Lafayette red loam, but supporting a rather different forest growth, and exhibiting somewhat different topographic characters. This soil washes readily into deep gullies. The timber growth is post, black and Spanish oaks, hickory and poplar. The topography is rather broken—steep rounded hills—the exact counterpart of what may be seen just north of Marion and Greensboro. About seven miles from Eutaw we see a peculiar conglomerate resulting from the alteration of a bed of greensand and made up of hollow almond-shaped concretions of ferric oxide held together by a ferruginous cement. The red soil along this road when packed by passing wheels has strong resemblance to limy clay, and in general the soil is much like that of the post oak prairies.

At Merriwether's Landing we have the following section:

Section at Merriwether's Landing.

1. Dark gray laminated clays with sand partings. At the bottom lignitized trunk with perforations filled with iron pyrites. In these clays there are streaks filled with leaf impressions which

are, however, not sufficiently perfect to be determined. . 15 feet.

2. Sands and clays in many alternations, more clayey above sandier below. These beds hold several irregular beds of pebbles, many of which are of hard clayey matter..... 30 feet.

At this place the great irregularity in the bedding of the Eutaw sands, described in detail in the general part of this report above, may be best seen. Eutaw stands just at the junction of these sands with the calcareous beds of the Rotten Limestone, which appears in patches in all the fields to the southward of the town. The relations of the Eutaw beds along the river are given in detail in the general part, and need not be repeated. These strata northwestward from Eutaw exhibit about the same characters as along the road from Tuscaloosa. About Eutaw the phosphatic beds which always occur at the junction of the Rotten Limestone with the sands, are to be seen in many places. At Pleasant Ridge these contact beds may be seen in the ravine of the tributaries of Turkey creek, which head up near the town. The town is upon the high hill capped with the red loam and pebbles of the Lafayette. Below these surface beds we come first upon a thin bed of the Rotten Limestone, and below that into a series of laminated clays with cross-bedded sands, holding many lignitized trunks, and beds of lignitic matter. The lignitized trunks are perforated with worm holes now filled with pyrite. Much of these strata have decided greenish color, due, not so much to the presence of true greensand, as to a green coating on the grains of quartz sand. Among these strata are many nodules and casts of shells, etc., of phosphatic matter, analyses of which are given in another place.

Southward of this belt of the Eutaw sands, the rest of the county rests upon the strata of the *Rotten Limestone* or *Selma Chalk*. This, like all the other strata of the Coastal Plain, has the covering of Lafayette sands, loam and pebbles, now in great part removed by erosion in certain sections, such as the vicinity of the Tombigbee River and in the fork between the

two rivers. This county has, therefore, a very large proportion of prairie or limy lands, interspersed, however, with the usual strips of sandy soils.

The railroad from Eutaw to the river at Jones' Bluff crosses much of the prairie country, well seen about Hayesville, Boligee, etc.

But for the little sandy hills below mentioned, the surface of the country underlaid by the Rotten Limestone, is very little diversified. Occasionally low knolls rise above the general level, timbered with cedar or more commonly destitute of trees. These bald spots occur also even in the level lands, where the rock comes near the surface and has very slight thickness of soil over it. The most important feature connected with this formation is the soil resulting from its disintegration, a deep black, clayey, calcareous soil of great fertility, but which has everywhere in Alabama suffered greatly from neglect and from improvident cultivation. This soil, which is the perfection of a soil in dry weather, becomes the most intractable of clays when thoroughly wet by the rains of the winter.

That part of Greene to the southward of Eutaw, in the direction of Demopolis, has been well described many years ago by Prof. Tuomey. "About a mile below Eutaw the calcareous deposits of that part of Greene included between the Tombigbee and the Warrior rivers, called "The Fork," commences; the beds thicken rapidly, as is exhibited in the deep borings for water, and are surprisingly uniform in mineral character; whilst the absence of streams and ravines, added to the unbroken surface of the entire region, renders the study of the underlying rocks extremely difficult, so that it becomes at once evident that the geologist who would work out the structure of the Cretaceous formation of the state, must confine himself principally to the natural sections presented in the river bluffs."

"For many miles the surface is slightly undulating, and almost the only change that could be perceived in the limestone, presented itself in the ledges of rough and rather

hard rock, which occasionally occur on the brow of the slight elevations of surface scattered over the country. This rock has the appearance of having been perforated in all directions, which suggested the name 'bored rock,' by which it is known here."

"A peculiar feature in the geology of the 'Fork,' consists in the numerous isolated conical hills scattered over the country; they are composed of sand, pebbles and clay, and if they did not present indubitable evidence of their origin, one might mistake them for artificial mounds on a magnificent scale. They give rise to springs, the water of which is free from the usual impurities of the limestone, and they furnish, in many other respects, desirable sites for the residences of the proprietors of the land. Differing so entirely from the rest of the country, it is not surprising that these elevations should have excited attention, and given rise to speculations as to their origin."

From this account it will be seen that the Lafayette beds of which these hills are remnants, overlie the strata of the Rotten Limestone in the "Fork," as they do those of the other formations in the northern part of the county. Although Prof. Tuomey says nothing about the altitude at which these beds occur, it is to be supposed that they are found here as in the other parts of the county up to altitudes of 400 to 500 feet above mean tide. Certainly also they appear at much lower levels, and especially the third terrace of the river is made of these beds, a red loam above with pebbles and sands underneath.

The *Second Bottom* deposits along the river are well developed, and a detailed section is to be found above the general part, of the typical deposits of this age at Logan's Bluff.

HALE COUNTY.

In this county we have for underlying formations the three lowest divisions of the Cretaceous. The northeastern quarter is underlaid by the beds of *Tuscaloosa* age, which

are well exposed along the road from Tuscaloosa to Greensboro. Along most of the slopes leading down to the streams crossed by this road, erosion has exposed the sands of the Tuscaloosa formation, in places very difficult to distinguish from the similar sands of the Lafayette which once covered all. The Tuscaloosa clays, on the other hand, are easily recognized, both by their peculiar massive appearance and generally also by their color, which is variegated with shades of purple, gray, and brown with white, as well as by the fact that where they crop out along the road, there is necessity for laying causeways in order to render the roads passable. At Havana we come upon a high level plateau capped with a ferrile red loam, probably of Lafayette age, but with the sands of the Tuscaloosa exposed in all the gullies which make off from the main plateau. Near the place of Hon. A. M. Avery there are several gullies in which the pink and variegated sands which make the uppermost strata of the Tuscaloosa are well shown. This section is well described above on the general part of this report, and is illustrated by a view, Plate XVII, which will render further description here unnecessary. In the vicinity of Havana, and extending also down to the river at least, is a conglomerate made of the pebbles cemented with the oxide of iron, which appears to belong to the overlying Lafayette, and which is the cause of the formation of a rocky glen back of Havana village, in which some of the rarest ferns in Alabama are now growing. This glen is also the home of a number of other plants of uncommon occurrence in this state.

Through all this territory the long leaf pine is the prevailing tree, associated with the usual upland oaks, especially upon the red loam plateaus, where the pine often fails entirely. The Tuscaloosa strata are also well exposed along the river banks, as has been sufficiently well shown in the general part of this report.

A few miles below Havana yellowish red cross-bedded sands with thin partings of gray clay make the country for some distance, and the surface is much more hilly and the vegetation quite different from what prevails over the Tuscaloosa strata to the northward of Havana. Here the timber is post, black, white, and red oaks of great size, sour gum, umbrella magnolia, short leaf pine, and hickory. These sands have evidently been derived from the weathering of glauconitic sands of the Eutaw, and the yellowish or reddish color comes from the iron of the glauconite. These strata with increasing degree of sandiness and with corresponding increase in the proportion of the pines among the other trees, continues down to Greensboro. Eight and a half miles north of Greensboro the following section exhibits the general characters of the Eutaw sands in this part of the state:

Section of Eutaw Strata 8 miles North of Greensboro.

1. Cross-beeded ferruginous sands, with lamellæ of gray clay, 20 to 30 feet.
2. Gray laminated clays .....2 to 3 feet.
3. White sands, strongly cross-bedded immediately below the clays, 5 feet.
4. Cross-bedded ferruginous sands to base of hill.....20 feet.

The ferruginous sands are plainly the *residua* from the weathering of glauconitic sands. Where the lines of bedding of these sands are obliterated it is often very difficult to distinguish them from the Lafayette loam, except perhaps by the general appearance of the country and by the timber growth, which, though made up of the same trees that cover the Lafayette terranes, has quite a different aspect. All the country made by the Eutaw sands in this part of Hale is broken or at least rolling and fertile, and the soils of a peculiar yellowish red color. Besides the trees enumerated above we find often the following also, sweet gum, poplar, and ash. In some places cedar and short leaf

pine may be seen together forming dense thickets. In this territory also, where the divides are wide enough they are in the form of level plateaus with the usual capping of the red loam of the Lafayette with its accompanying under bed of water-worn pebbles. Upon the narrower divides these red loams are not so often seen as they have in many cases been removed by erosion.

The town of Greensboro is situated upon the dividing line between the Eutaw sands and *Selma Chalk* or *Rotten Limestone* and, as is usually the case in such localities, the soils show the effects of the admixture in the red or yellow, somewhat sandy post oak soils, interspersed among the rich black calcareous clay soils of the prairies. Along this horizon also occur the most important of the phosphatic greensands of the Cretaceous formation. This stratum is well exposed at Cocke's Mill a few miles from Greensboro. It may also be seen at many places in the farm of Mr. T. K. Jones a few miles from town. From Greensboro southward to the county line, we have the Selma Chalk exclusively except where it is covered by the Lafayette sands, and the country, though rather monotonous is from an agricultural point of view, exceedingly interesting. The strata of this formation can be seen best along the river, where they make many high bluffs as at Arcola, Millwood, etc., and these have been described in detail above in the general part relating to the immediate vicinity of the rivers. Through all this lower part of Hale, there are rounded white knolls formed by the outcropping of the limestone, which are sometimes covered with a dense growth of cedars, as between Demopolis and Prairieville. In many parts of this region the stratum of soil is so thin that large trees can find no support, and only a shrubby or herbaceous growth can flourish, and this circumstance has given rise to the name "prairie" applied to them originally, a name since so extended as to include all areas with the stiff, calcareous, usually black soils which

characterize these bald places of true prairies. In these parts the streams have excavated the channels in the limestone rock, the banks being in many cases as smooth and as regular as if artificially made. In this territory the water supply is mainly from artesian wells or else from cisterns which are dug into the rock itself and merely coated with cement. These soil varieties and their characteristics have been described at some some length in the Agricultural Report published in 1883.

In the lower part of Hale not far from Prairieville, a ridge crosses the county from east to west, and extends into Perry beyond. This ridge is some 60 or 70 feet in height and owes its existence to a stratum of pure limestone interbedded in the usual clayey limestone of this formation. This purer rock is often burned for lime for which it answers well. It is characterized by being perforated with holes which has given rise to the name "bored rock" so commonly used to describe it.

Prof. Tuomey explains this bored rock from observations made by him at Arcola, where he saw the white pure limestone pierced in every direction with cylindrical and variously shaped nodules of argillaceous matter, much softer than the rest of the rock, and from this reason easily washed out by rains, giving the rock this remarkable structure. The segregation of the clay into these concretions will also perhaps account for the relative purity of the limestone.

Of the later formations we have in Hale as in most of the counties of the Coastal Plain the Lafayette and the Second Terrace deposits. The *Second Bottom* lands along the Warrior river show the usual characteristics so often referred to above. They occupy a narrow terrace of less than a mile width on an average. Above this at an elevation of 100 feet or more above the water level follows the third terrace which will average some two or three miles in width, and which

has for its surface material a red loam underlaid with pebbles, of the usual Lafayette character.

Beyond this terrace the country rises somewhat abruptly to the general level of the plateaus which is four hundred feet or more above the water level in the river. This plateau has for its surface material the same red loam and pebbles that cap the third terrace. Where the streams run near together this plateau is often obscurely marked and the country is merely hilly, but where the divides are wide the plateaus are well defined. We have already made some mention of the plateau upon which Havana stands. This is some five miles long and three or four wide, with hardly an interruption to the level till the edge is approached. Along many of the slopes leading down from this plateau the capping of red loam with its underlying pebbles lies with nearly uniform characters as regards thickness and relative position of loam and pebbles. It seems at times impossible to conceive of this spreading of the materials along the slopes, as being the result of the redistribution of the materials consequent upon the erosion of recent times.

PERRY COUNTY.

This county, like Dallas, on account of its great extent from north to south, embraces within its borders the representatives of the four subdivisions of the Cretaceous formation, and exhibits in consequence a great variety, both in its topography and in its soils. The northeastern part, down to a line connecting Perryville and Marion, is underlaid by the *Tuscaloosa* beds; cross-bedded sands of various colors, with beds of massive or joint clays, of mottled red, purple and brown to gray colors. In all this section the country is somewhat hilly, and the surface soil, being formed either by the sandy strata of the Tuscaloosa or the equally sandy beds of the overlying Lafayette, supports a growth of long leaf pine which in places is unequaled in any part of the state.

In the northern part of Perry, about Ironville and Jericho, the hilly country is composed of purple clays 9 to 10 feet in thickness, resting on 4 to 6 feet of gray clay, which in turn overlies 20 to 25 feet of cross-bedded sands. Upon the summits of the ridges, and protecting them from erosion, are plates and crusts of ferruginous sandstone which occasionally becomes fairly good liminite as in the vicinity of Ironville.

The iron-capped ridges continue on eastward, and on the divide between the waters of Oakmulgee and the Cahaba rivers, in township 21, ranges 9 and 10, the iron crust is 15 inches in thickness upon high hills, the slopes of which are strewn with its fragments.

East of the Oakmulgee, in S. 1, T. 20, R. 10, an exposure of the Tuscaloosa beds gives the following section observed by Mr. Langdon:

Section of Tuscaloosa Strata.

1. Red loam containing limonite plates and specks of white clay 20 feet.
2. Mottled clay, purple and gray .....8 feet.
3. White sand with many small white angular pebbles.....2 feet.
4. Mottled clay, purple, gray and yellow, merging gradually into the next succeeding bed.....4 feet.
5. Yellow micaceous sands; where exposed the surface becomes indurated into sandstone, the cement being limonite..... 2 feet.

Near Sanders's Mill, six and a half miles north of Marion, on the Centerville road, Mr. Langdon describes a section in which some 25 feet thickness of cross-bedded sands are exposed. These sands, which vary in color from greenish yellow to red and black, are disposed in narrow bands from eight to ten inches in thickness each. The black seams from a distance appear to be lignite, but on closer examination prove to be colored by manganese*. All these sands

*It is possible that this black color is due in part to iron, for similar black sands and black sandstone have been noticed at many points in this state as well as further northeastward, in Maryland and elsewhere, which, upon chemical examination, showed no trace of manganese, though iron was abundant. E. A. S.

weather to a red color. In a gully large fragments of a black sandstone were seen with the black cement. In the sands above mentioned were numerous thin seams or lamellæ of gray clay, one-quarter to half an inch in thickness.

Nearer to Marion the probable contact of the Tuscaloosa with the *Eutaw sands* occurs. Thus, Mr. Langdon gives the following:

Section two miles North of Marion.

1. Gray laminated clays.....2 feet.
2. Red, cross-bedded sands.....4 feet.
3. Laminated gray clays.....4 feet.
4. Strata not seen, covered by washings from above.....15 feet.
5. Purple sands, whitish at top.....10 feet.
6. Gray laminated clays.....1 foot.

The cross-bedded sands with clay partings are seen then in all the cuts to the town of Marion, which is situated upon a high hill of these strata overlooking the trough of the Rotten Limestone to the southward.

In all the washes and cuts about Marion the cross-bedded sands with dark gray laminated clays are exposed. These are capped everywhere with the red loam and pebbles of the Lafayette, the pebbles not being very numerous at Marion but becoming abundant a mile east of the town and continuing so in the direction of Perryville. This village is upon a high red hill at least 200 feet above the lowlands of Oakmulgee. The greater part of the hill is of the cross-bedded sands, etc., of the Eutaw formation, but the summit and much of the slope are covered by the Lafayette red loam and pebbles. In no place can the mantle-like character of the Lafayette be better seen than along the road leading down towards Oakmulgee eastward from Perryville. This mantle of red loam and underlying pebbles lies upon an eroded surface of the Eutaw sands, the beds of pebbles being of irregular thickness but always below the red loam. The

average thickness of this covering will be about 15 or 20 feet all the way down the hill.

Below Marion the Eutaw sands show similar sections to those above given. At Old Humburg, which lies immediately upon the junction of these sands with the lowermost beds of the *Rotten Limestone*, are seen many things of interest. The sands at this horizon are filled with fossils mainly in the form of casts or moulds, and these moulds are invariably phosphate of lime. Many of them are weathered and water-worn till the organic character is well nigh obliterated, and they appear to be merely irregularly shaped concretions of phosphate of lime. It is possible, however, that some of the phosphate pebbles are of the nature of concretions.

In the fields of Mr. Spencer at this place, the contact of the two divisions of the Cretaceous are well exposed and are typical. This section is as follows:

Section near Hamburg.

1. Rotten limestone, overlapping in thin layers but becoming thicker towards the south.
2. Phosphatic greensand with a tendency to indurate into hard ledges 4 to 5 inches in thickness.....2 to 3 feet.
3. Calcareous bed with many phosphatic nodules covering the surface, and also sparingly disseminated through it....5 to 6 feet.
4. Ledge of whitish indurated marl, about.....8 to 10 inches.
5. Sandy shell marl, in places made up of small oyster shells, 1 foot.
6. Yellowish white, highly micaceous sands, with great numbers of sharks' teeth, indurated at intervals.....25 to 30 feet.
7. Laminated compact sands with greensand grains.....15 feet.

Compact blue sands with greensand to water level.

It is probable that numbers 6 and 7 are the same but differing only in degree of oxidation. Ledge number 4 and the shell beds underlying are most easily traced through all this section. Details concerning the phosphatic materials of this horizon and place, are given in the chapter on the marls, to which the reader is referred.

The lower part ot Perry is made of the strata of the *Selma Chalk* or *Rotten Limestone* which presents the usual uniformity of composition and of soils and topography. Traversing Perry as well as Hale to the westward, there is a ridge which owes its existence to a ledge of tolerably pure and compact limestone; in many places it has been burned for lime. This ledge is crossed about five miles north of Uniontown, near Hardee's Camp. Within three miles of the town the Rotten limestone becomes dark colored and more clayey and shells of varieties of oysters are abundant. Uniontown stands upon a characteristic type of this rock, bluish when wet but light gray or nearly white when dry. The bare rock is exposed at many points about the town, but in the low lands the rich black soils are among the best in the country.

In the extreme lower corner of Perry, in township 16, range 6, the *Ripley beds*, in the form of gray calcareous sands, come in, lapping up on the Rotten Limestone strata. As usual there is a transition belt from the black lands of the latter to the sandy lands of the former, where the reddish soils are of a rather stiff, somewhat clayey, character, with post oak as the characteristic growth. These lands are better seen in the adjoining parts of Dallas and Marengo.

Agriculturally, Perry may be divided into two parts, the upper of which embraces somewhat more than half the area, while the lower is characterized by the prevalence of the black prairie soils of the Selma Chalk. In this county, as elsewhere, this Chalk region is interspersed with ridges and hills capped with the sands and pebbles of the Lafayette overlying the limestone, and in most cases accounting for the existence of the hills. In the northern section the presence of this *Lafayette* mantle is much more general, as it occurs upon all the level plateaus separating the various drainage basins, especially where the divides are of moderate width.

The *Second bottom* deposits of Perry are of less importance than those of the counties bordering the larger rivers, and they are rather more sandy.

AUTAUGA COUNTY.

The underlying strata of Autauga are all Cretaceous, the upper half being of the Tuscaloosa series, and the rest chiefly of the Eutaw, while a moderately narrow strip along the Alabama River represents the Rotten Limestone.

The *Tuscaloosa* beds are reddish and yellowish sands, usually strongly cross-bedded, purple sands, and purple clays. The occurrences of the outcrops of these beds in Autauga have been described in considerable detail above in the general account of this formation, and it does not seem to be desirable to repeat the descriptions here. Over all the territory underlaid by the Tuscaloosa, in this county, the pebbles and sands and red loam of the Lafayette formation have been spread, and where denudation has removed little or none of these beds, as for instance upon the divides, they are responsible for the soils. In the drainage areas, however, of the creeks, these overlying materials have, in places, been washed off, and then the Tuscaloosa sands and clays make the surface. It is often quite difficult to distinguish between some of the strata of the Tuscaloosa and corresponding ones of the Lafayette, and for many years they were not discriminated, and all the beds of this belt were referred to as the Post Tertiary, i. e. to what we now term the Lafayette. Both formations have sands and loams as the prevailing materials, but the loam of the Lafayette when characteristically developed, is a deep red colored material, usually spoken of as clay, very different from any of the material of the Tuscaloosa. In all this region in Autauga the long leaf pine is the prevailing tree. Where the soils are thin and poor and sandy the turkey, black jack, post, and upland willow oaks, are associated with it; with more clay

in the soil, the other oaks come in and the barren oaks disappear. Some of the finest pine forests of Alabama were once to be seen in the upper part of Autauga in the territory of the Tuscaloosa formation, but they have been almost completely cut away to supply the mills along the L. & N. R. R.

The sands of the *Eutaw* formation make the lower part of the county. This formation, though made up in the main of cross-bedded yellow and gray sands, makes a country much superior to that formed by the Tuscaloosa. This is no doubt due to the fact that in this section of the state a good deal of calcareous matter is mingled at intervals with the sands, and the soils resulting from their disintegration are of fairly good quality. Over these beds also the *Lafayette* mantle is found; and much of the soils especially upon the level high plateaus are due to this formation and not to the Eutaw. Good sections of the Eutaw strata are exposed along the banks of the Alabama River from the House Bluff up to Montgomery. These also have been described above in detail in the general account of the Eutaw formation, and to this the reader is referred. At Prattville, a good part of the hills surrounding the town are made up of the Eutaw beds which are chiefly cross-bedded yellowish sands with clay partings along the lines of bedding. Along with these sands there are beds of laminated clays, and where these underlie the sands along hill slopes they often cause land slides. The hillsides between Mrs. Julia Pratt's residence and the residence of Mr. Daniel Pratt show many such movements. This is particularly the case about the house and premises formerly occupied by Mr. Hutchinson, which are completely cut up by these landslides and the gullies to which they have given rise.

The bed and banks of Autauga Creek just below the upper dam, and also below the lower dam, are made of yellowish sandy clay, which contains many indications of the former presence of marine shells. These shells are now generally

completely decayed and nothing but a mass of pulverulent carbonate of lime, and sometimes the lime is in the form of concretions disseminated through the sandy clay or "marl" as it is usually callad.

This occurrence is mentioned because marine fossils are quite rare in this formation, and I know of none in it to the west of Prattville, though we see them again on the Chattahoochee River. The territory of the Eutaw sands is somewhat rugged and hilly, especially going down the slopes towards the streams, but the divides are generally level plateaus, often of considerable width and always of attractive appearance, since they are usually capped with a stratum of red clayey loam underlaid with pebbles, and the resulting soils are among the most desirable in the county, though not perhaps the most fertile.

As may be seen from the details given in the general part of this report, the lower strata of the *Rotten Limestone* division include a bed of greensand phosphatic marl and below that a ledge of oyster shells which make a tolerably hard conglomerate. In places this conglomerate is double the two parts being several feet distant from one another. Below this come the sands and sandy clays of the Eutaw. While the latter make up by far the greater part of the bluff of the river from Montgomery down to the edge of Dallas, yet from Old Vernon several miles down the river, we find the lower measures of the Rotten Limestone making the summits of the bluffs, and of course lapping over in a thin layer upon the Eutaw sands on the Autauga side of the river. This overlap gives rise to the formation of a large amount of good farming land all along the river and stretching out for a good many miles from the river upon the higher points and divides. These outlying areas are not shown on the map and the river is given as the line of separation of the two formations. The river fields about Mulberry and Autaugaville have this surface stratum of the lower part of

the Rotten Limestone, and nearer Prattville the Slaton place, the Jim Brown place, and others may be cited as localities where the same beds lie upon the Eutaw sands on the hills. In the river fields about Mulberry the beds of phosphatic greensand occur in favorable position for getting up and spreading upon the lands, and the same is true of the fields on the old Slaton place. The regular black prairie soils form but a very small proportion of the soils of the county.

We have said above that the *Lafayette* sands, loams and pebbles have been spread as a mantle now in part removed, over the whole area of this county, and enough of it still remains to be concerned in the formation of a greater proportion of the soils of the county than any other of the geological formations. The fine brown loam table lands in the central and lower part of the county are based upon the Lafayette, while the pine woods of the upper part are partly upon Lafayette soils, partly upon those derived from the Tuscaloosa sands. As we go down towards almost any of the streams in Autauga we come upon a bed of pebbles, and in most of the streams crossed in coming from Vinehill to Prattville the pebbles are more abundantly seen on the left banks of the creeks.

In this county the mantle-like character of the Lafayette deposits may be seen in perfection, for we meet these deposits at elevations differing by at least 100 feet, and at all these different heights the disposition of the beds and their structure appear to be identical.

Of later formations we have the *Second bottoms* of the river with the usual fertile yellow loam, and brick clay soil frequently spoken of elsewhere in this book. Another terrace which seems to be a little higher than the second bottom may be seen all along Autauga creek from its mouth up to Prattville. Here we have an almost level plain about a mile in width with a surface covering of deep sand supporting a growth of long leaf pine, turkey, black jack, and willow oaks,

along with some post oaks. These sands lie upon the Lafayette beds above mentioned and the stratum of pebbles may nearly always be seen along the outer margins of the terrace. Prattville stands upon this terrace which is there bordered by hills of Eutaw sands over which the Lafayette sands, pebbles and loams are everywhere seen.

ELMORE COUNTY.

The greater part of Elmore is underlaid by the Crystalline rocks and only the tier of townships along the Tallapoosa river and the Coosa below Wetumpka, and the part of the county lying next to Autauga have the Cretaceous for the substratum. West of the river the geology does not present any anomalies. We find both *Tuscaloosa* and *Eutaw* strata in their regular position, the former making the country from about Robinson's Springs or Coosada northwards, while the Eutaw forms the region to the southward of these places. It is to be observed, however, that the broad terraces of the river on this side take up a very considerable proportion of the territory. Thus from Wetumpka out to Elmore Station the country is almost perfectly level or at most there are a few shallow depressions where Calloway's creek crosses it. Then from Elmore to Coosada and thence westward for a mile or two the same level plain, while from Coosada southward this plain is continuous to Montgomery and thence down the river to the Autauga line. This terrace is covered with the materials of the Second bottom and of the Lafayette. From Elmore to Robinson's Springs and on to Prattville the country is hilly and underlaid first with the strata of the Tuscaloosa and later with those of the Eutaw. Neither of these, however, makes much surface show, for the pebbls, sands, and loams of the Lafayette cover nearly everything except at the low levels of the streams and even then it is rare to find any decided or determinable outcrop of the older strata. In all this section the hills have a cap-

ping of red loam of the Lafayete and the hillsides are generally strewn with pebbles of the same age, often of exceptionally large size, up to five or six inches dimensions. Large pebbles may be seen for instance on the road from Robinson's to Prattville in the edge of the Springs settlement, and beyond the first creek crossing.

The main wide terrace spoken of is the Third terrace, and it has a sandy soil and a red loam subsoil below which at depths of ten or fifteen feet a layer of pebbles. These do not show often on the terrace for the reason that very few streams cut down as deep as fifteen feet below the general surface. On the eastern side of Calloway's Creek they however are abundantly seen. This third terrace here is not more than ten or fifteen feet above the *Second bottom* terrace, which is of the usual character, a yellow loam surface with underlying sandier strata. A more detailed account of this formation will be given in connection with the account of the area included in the fork of the two rivers.

On the east side of the river we do not find the geological structure quite easy of determination. The crystalline rocks underlie all the county down to Wetumpka and Tallassee on the two rivers. Between the two places the country is nearly level or only very slightly lowered along the small streams that are crossed. The surface is sandy and seems in great part to be made by the products of decomposition of the gneisses, and angular fragments of the quartz sheets with which the gneisses are traversed are abundant. Among these angular fragments there are in places pebble beds with well rounded pebbles, which probably represent the Lafayette formation. Within two miles of Tallassee the Lafayette is unmistakably seen in the pebble beds and the red loam which forms the surface. The Lafayette overspreads the gneisses and other crystalline rocks to the northward as far as Central Institute, and in this part presents no unusual characters. To the southward of Wetumpka however, it shows certain aspects that will be more particu-

larly mentioned below. While, by analogy with the counties east and west of Elmore, we should expect to find the Tuscaloosa strata occupying the belt next south of the crystalline rocks in this county; such does not seem to be the case at any place yet visited by me, though Mr. Langdon describes such a state of things below Tallassee. A few miles a little south of east of Wetumpka at Mr. Adam Enslen's in section 20 township 18 range 19, at the foot of a ridge of gneiss, there are several acres of outcrop of Cretaceous strata which from their general aspect and the character of the fossils probably represent the lowermost beds of the *Rotten Limestone*, or, in other words, the Hamburg horizon. These strata consist first of a greensand marl which has some phosphate of lime in it, 2 to 4 or 5 per cent. Beneath this a considerable thickness of strongly calcareous clays containing many lumps and concretions of carbonate of lime, which cover the surfaces of the small knolls of erosion in the fields. The fossils observed are *Exogyra costata*, shells of *Inoceramus*, and fragments of *Radiolites lamellosus*. The counterpart of all this may be seen in many places in Autauga and Dallas and other western counties along the junction of the Rotten Limestone with the Eutaw. Other tracts of similar nature are in the Gaines field in section 22, in the Nix field, and the Lud Murrell field in sections 30 and 31, and on the Bozeman place, southwest corner of section 31 of this Township 18, Range 19, and the adjoining parts of sections 36, 1, and 9, of the townships which corner with the one specified. These marls are exposed where the erosion of small streams has removed the overlying strata, which consist of a great thickness, at least 200 feet, of coarse red sands, cross-bedded and with clay partings at intervals along the lines of bedding, the clay of white or light gray color. These sands resemble very strongly some of the sands of the Lafayette exposed along the river road from Columbus to Eufaula, but they are not of the usual Lafayette type. In all this region however, the red loam and worn pebbles of the regular typical La-

fayette aspect, cap the hills the body of which is formed of the coarse red sands described, The pebbles of this capping Lafayette are sometimes very large, 6 to 8 inches in longest dimension. From the Hogarty Hill which is in or near section 5 of township 19, range 19, one overlooks the valley of the Tallapoosa beyond which the range of hills of Eutaw sands upon which the city of Montgomery stands is in plain view six or eight miles distant. Now when one considers that the Rotten Limestone sets in regularly beyond this range of hills to the south, these outlying tracts of it so far to the north, and at considerably lower level, become difficult to explain except upon the supposition of a depression of several hundred feet, the whole thickness of the Eutaw strata and perhaps more, along the border of the crystalline schists. Such a depression or warping seems to be indicated also by the apparent absence of any outcrop either of Eutaw or of Tuscaloosa strata between these marly spots and the Crystallines at Wetumpka. In no place could the strata underlying the marls above spoken of be discovered since erosion has cut down no further than the marls, but we may infer that both the Eutaw and the Tuscaloosa lie below, and that the whole series was deposited the relative altitude of the Wetumpka ridge of crystalline schists remained practically unchanged, thus allowing the deposit of each age to be covered completely by those of the succeeding age. Just north of the marl tract at Mr. Enslen's, upon the flanks of the gneiss ridge, there are some beds of bright red and purple colors that at first sight would be considered as of Tuscaloosa age. Upon close examination, however, one is entirely in doubt about them.

They consist of purple, white, and yellow sandy clays lying in well defined beds showing a strong southeasterly dip of 60 to 70 degrees, and northeast strike, precisely like these of the crystalline rocks adjoining, For this reason one would be inclined to consider them as merely residual matter from the decay of these crystalline rocks, and this is well borne out by what may be seen in the river banks at

Columbus, Georgia, or rather on the Alabama side opposite, where the residual matters from the decay of the gneisses there have the bright variegated colors and general appearance of the beds in question at Wetumpka. Now, at Columbus we are not left in any doubt as to the origin of these variegated beds. In these clays or sands at Mr. Enslen's the beds with different colors are quite sharply defined from one another, which also tells for their being residual matters in place over the original rock.

The area of the calcareous Cretaceous beds exposed in this manner about Wetumpka may be estimated at about 40 or 50 acres in all. The tracts lie in the erosion hollows above mentioned 200 feet or more below the summits of the sand and pebble hills that surround them. The great bulk of the sands composing these hills are coarse of grain, reddish in color, strongly false-bedded, with thin sheets of white or gray clays along the lines of bedding, and they are in places strongly micaceous. On going down from the Hogarty hill towards the west, one sees a lot of pinkish and purple colored sands, strikingly like those of the Tuscaloosa exposed in the great gullies near Havana in Hale county, and in them occurs a bed of pebbles of strikingly non-Lafayette aspect. These circumstances combined with the fact that overlying the great mass of this kind of sand which forms the bulk of the hills, we invariably find a capping of red loam and rounded pebbles of the usual Lafayette character lead us to consider them residual sands. The sands in question strongly resemble the Eutaw sands, but they seem to overlie without any question, the marl beds which are almost certainly of the Rotten Limestone horizon, albeit at the base of the same. I should be strongly inclined to consider these sands as residual sands if I knew of any beds in the Rotten Limestone which yield such *residua*. They have far more strongly the appearance of residual sands than of Lafayette beds, and they must belong either to the Rotten Limestone or to the Lafayette. It becomes difficult in view of the above occurrences to account for the

outcrop of Tuscaloosa beds on the other side of the Tallapoosa at Cowle's Station. At the Bozeman place there is a very large exposure of the marl outcrops, and coming up the hills from these we pass into reddish and yellowish micaceous sands of the exact appearance of the Ripley or Eutaw sands. At one place there seemed to be a very strong dip in the sands by which they appeared to pass below the marly strata, but I could not be certain that this was a true dip.

To the southeast of Wetumpka, along the Buck's Bridge road towards Cowles Ferry, the surface is generally formed by the sands, loams, and pebbles of the Lafayette formation, some of the pebbles being of large size, up to six or eight inches in length. Below this mantle come the strata of the Cretaceous formation, in most cases mottled clays and cross-bedded sands, impossible to classify with certainty, because of absence of fossils, and of sufficiently characteristic lithological features. There are however, one or two exceptions to this, viz., within five miles of the town, where there are several occurrences of the white marly clay with lumps of pulverulent carbonate of lime, of the same general character as the phosphatic marls about Enslen's, though without fossils; and in the river bank near Cowles Ferry, where strata of the Tuscaloosa formation are unmistakable. The section exposed just above the ferry is as follows:

Section near Cowles Ferry, Tallapoosa River.

1. Second bottom deposits..... 15 feet.
2. Whitish and yellowish sands..... 5 feet.
3. Purple clayey beds..... 3 feet.
4. Gray and yellowish-white sands, somewhat evenly laminated, nearly horizontal..... 6 feet.
5. Reddish and purple clayey sands, with irregular spots of gray color, down to water level..... 5 feet.

The beds 4 and 5 or rather indurated, and weather into rounded bowlder-like masses, of considerable hardness.

Along the road indicated, the crystalline rocks show in the bed of a small creek about five and a half miles from

town, but with this exception none of the crystalline rocks have been observed below Wetumpka.

In the south-eastern part of the county, there is a large area of magnificent pine timber, now being rapidly cut off by the Tallapoosa lumber company.

The second terrace or Second Bottom of the Tallapoosa river, from near Tallassee, southward to the bend of the river at Cowles Ferry, and thence westward down the river for some distance, affords some splendid farming lands.

Of the formations of Elmore later than the Cretaceous we may mention the Lafayette and the Second Terrace deposits. The *Lafayette* has already been spoken of in some detail as overlying the Cretaceous below Wetumpka, and also the crystallines above Wetumpka to Central Institute, and of this we need say no more. The *Second bottom* deposits are also well displayed in the county and especially below Wetumpka where the two rivers approach each other, making a wide area of this character.

Just below the site of old Fort Jackson a "cut off" has been established between the two rivers in which is laid bare a perfect section of these beds down to the water level. This has already been given in detail above in the general part, but will bear repetition here.

Section exposed in the Cut-off below Wetumpka.

1. Second bottom materials of the usual character, yellow loam at top with sandier beds below..... 25 or 30 ft.
2. Blue clay filled with vegetable remains in the form of stumps, twigs, etc., in almost perfect state of preservation. This stratum forms the bed of the cut-off and may extend several feet deeper. About 5 or 6 feet exposed.

The second bottom soils are always first class farming lands and being of fairly uniform character in the different parts of the state, they exhibit no special features here.

MACON COUNTY.

Most of Macon county lying in township 18 has for surface materials either the *Crystalline rocks*, gneisses, mica

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MACON COUNTY.

ost of Macon county lying in township 18 has for sur-materials either the *Crystalline rocks*, gneisses, mica

schists and quartzites, or the sandy soils with quartz fragments resulting from their disintegration.

These are well displayed along the road leading from Tallassee to Notasulga. The topography here is very gently undulating, the road excellent, being nearly level and firm with a few sand beds. The *Lafayette* which usually covers everything from this latitude southward is either very thin or absent along this section. The same may be said of the *Tuscaloosa* strata which do not make their appearance until the lower border of this line of townships is reached. Thus we see along a road travelled in 1891 from Notasulga towards Society Hill, the first of the mottled clays and cross bedded sands of the Tuscaloosa near Farrell's or Vaughan's Mill on Chechoctefala or Farrell's creek, S. 30, T. 18, R. 25 E.

From that point southward to Society Hill and probably a short distance below, characteristic sandy pine hills with long leaf pine, black jack, turkey, and upland willow oaks, prevail. Among the sands are irregular beds of pebbles and also of white and mottled clays.

Near Cowles Station Mr. Langdon has described a good section where the Tuscaloosa beds are shown near the site of old Fort Decatur in section 20, T. 17, R. 22 E.

Section of Tuscaloosa strata. Cowles Station.

1. Lafayette pebbles in light grayish yellow matrix. Pebbles rather small, mainly quartzese but occasionly hornblendic... 6 feet.
2. Yellow coarse grained sand shading to light purple. Contains a few small quartzose pebbles, and bits of clay. The sand is slightly argillaceous..... 10 feet.
3. Purple and greenish micaceous sandy clay with a few small quartzose pebbles. The upper and lower parts have a banded appearance..... 12 feet.
4. Greenish and brownish highly micaceous sand, with dark grains of hornblende or black mica. It is slightly argillaceous and strongly cross-bedded..... 8 feet.
5. Greenish and purple mottled sandy clay ..... 4 feet.
6. Yellow and gray coarse grained sand..... 4 feet.

While this section is closely descriptive of the exact locality, it will not correspond in all its details with the profiles exposed in other cuts in the immediate vicinity, for the beds are of irregular thickness and of varying composition horizontally. A bed of coarse sand and pebbles will pass in a few hundred yards into a mottled sandy clay with the gradation so imperceptible as to make it impossible to draw a sharp line between them. The purple and yellowish sandy and clayey beds of this formation are exposed in many of the cuts along this railroad to the eastward of Cowles.

To the southward of the belt of Tuscaloosa materials follows a strip some six miles in average width underlaid by the *Eutaw sands*. These form the greater part of township 16 and the lower part of 17. The Eutaw sands are grayish cross-bedded sands weathering to red or yellow colors. They are generally marked by thin sheets of gray clays along the lines of the false bedding, and rarely this far west contain any notable amount of lime, although the soils which result from the weathering of these sands are rather better in quality than the usual run of sandy soils, which would point to the presence of some lime in them. Over the greater part of this territory the surface is formed by the sands and loams of the Lafayette formation, so that it is at times very difficult to discriminate between them and the *residua* from the Eutaw sands. A fairly good section of the strata of the Eutaw in Macon county may be seen along the rood four or five miles south-east of Tuskegee, where a capping of Lafayette sands and loam makes the summit of a hill, below which follow 8 or 10 feet of whitish micaceous cross-bedded sands, then 4 feet of reddish sand, then 20 to 25 feet of light colored micaceous sands with strongly marked cross-bedding.

To the southward of this belt of Eutaw strata in the western part of the county we find an irregularly shaped area of the *Rotten Limestone* beds. These do not seem to extend beyond range 24 E. and in the eastern part of the county the Eutaw is succeeded immediately by what appear to be Ripley marls. It is possible that some of the strata

which we have assigned on lithological grounds to the Ripley may be of the age of the Rotten Limestone but with changed physical characters. The area above named of the *Rotten Limestone* shows the usual type of rock, i. e. a clayey limestone of bluish color, drying out to gray or nearly white, and disintegrating into a stiff marly soil which is usually or often of black color because of the amount of the vegetable matter in it. This class of soil is usually designated in Alabama "prairie" soil. Along the border of this with the Eutaw sands we nearly always find a transition edging of stiff lime lands with yellow clayey soil, which may perhaps best be considered as due to the intermingling of the sandier with the more clayey beds, and partaking of the characters of each in some degree.

On such lands the prevailing timber is post oak, and for this reason they are often spoken of as Post Oak Prairies. The Rotten Limestone or black prairie lands are encountered along the many streams heading up near the foot of the Chunnenugga ridge. They are met with along Persimmon Caleebee, Cupiahatchee, and Town creeks and their tributaries. Between these, the highlands are often capped with the sands of the next overlying Ripley and these in turn often by the Lafayette strata. The prairie strips extend up these creeks to the southern border of the county and in most cases far into Bullock.

The southeastern part of Macon has for underlying strata the sands, clays and shell beds of the *Ripley*. The massive clays of this formation give rise to stiff "hog wallow" prairie soils which are seen about Creek Stand and southeastward. The interbedded shell accumulations in some cases exert a favorable effect upon the soils. Chunnenugga Ridge or the extension of it as a divide between the waters flowing into the Chattahoochee and into the Alabama rivers, crosses the southeastern corner of Macon and shows the usual characters given under Bullock. To the north and west of the ridge the Rotten Limestone may be seen in most of the creeks val-

leys while to the south and east the Ripley strata prevail and the ridge may therefore be considered as approximately dividing the two.

RUSSELL COUNTY.

Russell county exhibits in its structure three divisions of the Cretaceous, viz. the Tuscaloosa, the Eutaw, and the Ripley, besides the Lafayette and the Second bottom terraces of more recent age. The *Tuscaloosa* claims the upper half township of the county and its characteristics are well displayed along the road from Society Hill to Columbus.

The prevailing and I might say the only materials, are cross-bedded sands with occasional strings of pebbles, and masses of mottled purple and white clays imbedded at intervals in the same. For several miles east of Society Hill the road is along a tolerably level plain with the hills beyond Uchee creek in view towards the south. Where exposures have been made by the small streams tributary to Uchee we see cross-bedded sands with irregular beds and strings of small subangular quartz pebbles dispersed through them. At Marvyn and a short distance eastward the same false-bedded sands and pebbles make the uppermost ten feet of the strata with massive mottled clays below them. East of Crawford similar mottled clays and pebbly sands disposed in the same order. Across Little Uchee and also about 7 miles from Columbus, the sands become decidedly feldspathic and are in places indurated so as to form rather hard sandstone.

To the east of Little Uchee the road passes over a high ridge, and descending this towards Phœnix City, we pass over some 200 feet thickness of the characteristic strata of the Tuscaloosa formation, red and mottled yellow and red cross-bedded sands, and mottled purple and white clays, the sands greatly predominating. Girard and Phœnix City are upon a terrace of Second bottom deposits to be more particularly described further on. Along most of the way between Society Hill and Columbus the soils are sandy and

of gray or lead color, and are underlaid everywhere at moderate depths by beds of pebbles. Along the slopes on each side of the numerous small streams crossed, beds of sand are frequent and deep. Part of this surface is made by the Lafayette sands and loam and in part it is derived from the Tuscaloosa materials which are very much the same in characters.

In the southern limits of the town of Girard the bluffs overlooking the river and back of the Second bottom terrace are composed of coarse cross-bedded sands of gray white and yellow and splotched with purple. In the upper part of these Tuscaloosa beds there are strings and pockets of subangular quartz pebbles in abundance. These are generally easily distinguished from the well rounded pebbles of the Lafayette beds which overlie here the Tuscaloosa.

A short distance below Columbus on the river road, a somewhat different class of strata is encountered; gray laminated clays with a certain amount of calcareous matter. These in all probability belong to the *Eutaw* division. Along the river, the sands, pebbles and the variegated clays of the Tuscaloosa above described make the banks down to the mouth of Upatoi Creek. Below this at the Broken Arrow Bend, these beds are seen at water level with some of entirely different characters overlying them and these we assign to the Eutaw, although the shells which have been collected are not such as to enable us to determine absolutely the horizon. In the bluff at the Broken Arrow Bend some 20 feet of these fossiliferous strata are exposed. They consist of dark gray micaceous sandy clays with indurated ledges about two feet apart. These indurated ledges are more calcareous than the rest and show a tendency to form rounded or somewhat spherical concretions with calcite septaria through them. The shells are *Exogyra costata*, *anomias*, and casts of univalves. A few miles below this and not far above Fort Mitchell landing, these dark colored strata appear at the water level and above them are 20 feet or more of clayey strata of which the following is the detailed section:

Section above Fort Mitchell.

(1.) Clays, originally black, but on exposure and weathering turning reddish and crumbling down into small fragments ..... 5-6 feet.

(2.) Coarse sand and pebbles, with a good deal of calcareous matter, lying just above a narrow bench. Many large pebbles near the base of the series..... ..... 5-8 feet.

(3.) Ledge of highly fossiliferous clays, the shells mostly in the form of casts Sometimes a thin sheet of calcite replaces a part of the shell..... 3 feet.

(4.) Black or dark gray clays to waters edge .. .. 20 feet.

The concretions and dark fossiliferous materials of the Broken Arrow Bend lie below medium state of the water.

For a mile or two below Fort Mitchell landing there are similar bluffs of black clays with fossiliferous ledges, and overlying these, ten or fifteen feet of cross-bedded sands with thin sheets or partings of clay very irregularly disposed through them, and below these a considerable thickness of much weathered crumbling clays with vertical or nearly vertical fissures which have been filled with sand now in many casas indurated into pretty firm sheets of sandstone. Below these are dark gray clays again to the waters edge. Just above the mouth of Uchee creek a long bluff on the right bank of the river shows 15 or 20 feet of cross-bedded clayey sands holding a great deal of lignitic (semi-graphitic) matter. This is about the line of junction of the Eutaw with the Ripley as we interpret it. It must be said however, that the division is somewhat arbitrary, for although below this the bluffs soon show unmistakable Ripley fossils, there are none from this up the river to the last appearance of the Tuscaloosa strata which give certain evidence of the Eutaw horizon. In the western parts of the state the Eutaw except in its upper measures contains little of organic matters except those of vegetable origin, while here on the Chattahoochee the beds immediately overlying the Tuscaloosa contain marine shells in abundance, though unfortunately not sufficiently characteristic to enable us to say whether they may not belong to the Rotten Limestone

division, although lithologically the materials are not much like any of the Rotten Limestone strata occurring elsewhere.

Upon the hills away from the river these strata have entirely different appearance, being very generally weathered into reddish and yellowish sands and crumbling yellow clays, and it is not possible to identify them with those making the river bluffs except in a general way.

Beyond Flournoy's station along the railroad the sandy strata give evidence of the presence of a good deal of calcareous matter. In the hills lying to the north of Fort Mitchell station, there is a great thickness to be seen of cross-bedded sands with pebbles very much like some of the Tuscaloosa exposures further up the river. These may belong to the Lafayette. After crossing Uchee creek on nearing the Oswichee neighborhood, the road ascends to a beautiful level plain fifty feet or more above the lowlands of Uchee. This plain has for its surface material the red loam of the Lafayette with its sands and pebbles underlying, and below all the sands of the Cretaceous.

Beyond Oswichee on both sides of Ihagee creek the laminated calcareous clays of the *Ripley* are well exposed, and further on to the southern border of the county these and other Ripley materials are to be seen wherever the overlying Lafayette sands and loams have been removed by erosion.

Along the Mobile and Girard railroad the cuts at Fort Mitchell show yellow cross-bedded sands with clay partings and with irregular bunches or pockets of pebbles. In another cut are laminated purple and yellowish clays with 3 or 4 feet of sandy material grading into pebbles below, overlying them. At Seale we are nearly upon the border of the Ripley, for a short distance beyond appear the yellowish red clayey materials specked with red, which so often results from the disintegration of the Ripley strata. At Hatchechubbee the cut show a good deal of mottled clay overlying irregularly bedded sandy clays.

Southward of Hurtsboro in the lowlands of Cowikee creek there is a good deal of the hog wallow prairie, formed

from the weathering of a heavy joint clay of the Ripley. This kind of soil resembles that of the Rotten Limestone in texture but is of reddish color, where the other is generally black or dark gray. The timber is hickory, white, and Spanish oaks, and long leaf pine. In the drainage area of the Cowikees, sands frequently cover these joint clays, but the influence of the clays makes itself felt in the fertility of the soil notwithstanding its unpromising appearance. The divides between the streams are very generally capped with the pebbles and sandy loams of the Lafayette and support a tree growth of long leaf pine, black jack and post oaks.

In Russell county we have many opportunities of examining the characteristics of the *Second Bottom* deposits. Opposite Columbus, Georgia, there is generally a bench of second bottom materials, the usual yellow loam, which overlies in some cases directly the decomposed gneiss of the country, but in many cases between the Second Bottom and the gneiss, there is a variable thickness of beds of Tuscaloosa age, consisting of cross-bedded sands with irregular pockets of pebbles, and irregular beds of white and purple clays. The yellow loam of the Second Bottom has almost invariably a string of pebbles at its base.

BARBOUR COUNTY.

The area of Barbour county is about equally divided between the Ripley division of the Cretaceous on the north and the lower divisions of the Tertiary on the south. It thus presents a very great variety in its soils and topographic features.

The *Cretaceous* strata in this part of the state are known by the general term, blue marl. These beds are alternations of a tolerably massive clay with a bluish micaceous sand, which, when it contains many shells, goes by the name of marl, and, for that matter, the clay itself is often called marl. In the northern part of the county, in the drainage area of two upper forks of Cowikee Creek, there is a good deal of what is known as "hog wallow" prairie, which is based upon

this tough clay. This makes a soil somewhat like that of the Rotten Limestone, except that it is generally of a reddish color. In the immediate vicinity of the creeks and their tributaries the clay is tempered with sands, and the resulting soils are correspondingly easier of cultivation while at the same time more than ordinarily fertile. Upon the divides between the forks of Cowikee Creek the Cretaceous strata are covered by deep beds of white sand, which, notwithstanding their unpromising appearance, support many large farms. The sandiness increases, generally, towards the creeks. The Spring Hill ridge is capped with a bed of red loam underlaid by sands of the Lafayette age, and to the southward of Spring Hill, towards Hawkinsville, the clays are again exposed along the valley of the Middle Cowikee. The timber of the ridges in this section consists of long leaf pine, black jack and post oaks. Between Hawkinsville and Eufaula the joint clay of the hog wallow lands contains many white concretions of lime, and forms a whitish to reddish prairie soil which is timbered with the upland oaks, hickory and short leaf pine. In some parts of this section we find a rather unusual association of trees, viz., hickory, white and Spanish oaks, sweet and sour gum and long leaf pines, all with a draping of the long moss (*Tillandsia*). Approaching Eufaula, the bluish micaceous sands come in over the clays above mentioned, but similar blue marls occur also further north and presumably below some, or perhaps much of the clays.

In the banks of the Cowikees and in many of the deep washes about Eufaula the blue marl contains a great abundance of shells, which, in the perfection of their preservation and in the freshness of their appearance, rival those of the Tertiary.

Along the river road, at the crossing of Little Barbour Creek, the following section is seen:

Section of Ripley Strata.

(1.) Black sandy pyritous shales.....6 feet.
(2.) Alternations of sands with sandy shales, containing a few shells of oysters.....5 feet.
(3.) Gray and whitish pyritous sands to the water.....4 feet.

On ascending the hill to the south of this we see some 30 feet thickness of compact, blue, clayey sands overlying the first of the above section. These strata are covered, at the summit of the hill, by strata of the Lafayette consisting of coarse-grained, cross-bedded, reddish sands intercalated with strings of white pebbles irregularly distributed through them. This phase of the Lafayette, which is common in the drainage area of the Chattahoochee, is illustrated by Plate II, p. 81, prepared from a photograph taken by me in 1891. Another phase of the Lafayette not uncommon in this section exhibits red and yellow mottled sands which are, however, better seen in the hills on the opposite or Georgia side of the river. In the Chattahoochee drainage, also, there is a greater prevalence of mica among the sands of the Lafayette than is the case further west. This circumstance may find its explanation in the closer proximity of the Chattahoochee to the region of the crystalline rocks, the source of the mica. Along this river road, above Eufaula, are many opportunites of seeing the gray sands of the Ozark age, overlying the Lafayette, sometimes to the depth of 15 or 20 feet. In these sands, and especially towards their base, pebbles are common and often preponderate over the sands. The gray sands form an upper second terrace a few feet above the second bottom terrace of the river. Their prevailing, and at times only, growth is the long leaf pine.

That part of Barbour lying to the south of a line drawn from the mouth of White Oak Creek up to Clayton and thence westward to the border of Pike, has for its underlying rocks the strata of the Tertiary.

The lowermost of the Tertiary here is the *Clayton Limestone*, which consists of clays and limestones in alternating beds. A good section is exposed in the railroad cut near Clayton, which is as follows:

Section at Clayton.

(1.) Dark blue, nearly black, massive clays, turning yellowish white upon drying out.....10 to 15 feet.
(2.) Limestone.....5 to 6 feet.

This clay, which is exposed at many localities about Clayton, has the appearance of fire clay, but is rather light in specific gravity, owing, in all probability, to the circumstance that it was originally calcareous and that the lime has been leached out.* The limestone is in places much thicker than here seen, as is attested by the caves and lime sinks which characnerize the whole region underlaid by it, and which would not be possible with a thin bed of limestone. Outcrops of a hard, almost crystalline, limestone, with grains of quartz in some phases of it, have been observed by Mr. Langdon and myself over a very large area in Barbour, especially along the valleys of Pea River and of the tributaries of the Choctawhatchee. In some cases this limestone occurs to the southward of the lower limit of the Clayton as shown on our map, as, for instance, at Blue Springs; but then the strata of the Nanafalia are found upon the hills adjoining. We have not attempted to show these outlying areas. The exposure of the Clayton limestone is carried far southward along Pea River, as may be seen by the notes of Mr. Langdon, who finds it near Dr. John A. Reynolds, in sections 3 and 16 of township 9, range 24, and again near Mr. Robert Lee's, in section 2, township 8, range 23. In these places it has the same character as about Clayton, and is associated with gray, laminated, micaceous, somewhat calcareous clays, and with white and yellow calcareous sands, with numerous shells of oysters. This section is given in detail in Mr. Langdon's article. The limestone is highly fossiliferous, the shells being very generally silicified.

At King's Bridge, near the southwestern corner of township 9, range 26, there is a hard, almost crystalline lime-

*Microscipic examinations show that these clays contain large quantities of the silicious shells of *diatomaceæ*, etc., and are hence in part, *tripolis*.

stone, overlying a sort of shell breccia resembling the coquina rock of Florida. No determinable shells were observed here, so that the horizon could not be certainly fixed, yet this is probably the Clayton Limestone, notwithstanding the fact the fragments of the pseudo-buhrstone of the Nanafalia outcrop on the hill hard by. Again at Blue Springs we find a great body of limestone water gushing up through a fissure or crack in a limestone rock which seems to be no other than the Clayton Limestone, although Blue Springs lies near the southern border of the Nanafalia outcrop. The limestone is probably kept thus near the surface by an undulation in the strata, or a flattening of the dip, such as may be seen at many other points in this section of the state, and is exposed by the removal by stream erosion of the overlying Nanafalia beds which probably here do not have any considerable thickness.

The Clayton strata seem to be nearly two hundred feet in thickness in the vicinity of the Chattahoochee, but the opportunities for seeing a continuous section are very few. It seems almost certain that there are at least two, and perhaps three, limestone beds, interstratified with the other beds of this division.

At the base of this, or at the summit of the Cretaceous, in any event near the junction of the two formations, beds of fairly good limonite or brown iron ore are common not only in Barbour but as far westward as Butler county at least. Some of this ore is fibrous or needle ore, and where the quantity is sufficiently great it will be valuable. Occasionally at this horizon we encounter ferruginous sandstone with shell casts, as, for instance, a few miles west of Eufaula, on Clayton road. The *Clayton Limestone* and the stony clays above mentioned do not form any great proportion of the immediate surface, which is generally due to the beds of Lafayette age, consisting of brown and reddish loams, underlaid with sandier materials which are commonly cross-bedded,

and which contain irregular masses or bosses of white and purple colored plastic clay. Such clay masses occur irregularly in the cross-bedded sands, usually with a ferruginous hard pan separating them. The sands themselves are different from the great body of the sands of the Lafayette, in the other parts of the state, being yellowish and reddish cross-bedded material with white clay partings along the lines of false bedding. The sands are also at times fine and of floury consistence, and are very generally micaceous. Occasionally, also, they are variegated, yellowish and pink or purple, and the general effect recalls what we see among the upper strata of the Tuscaloosa formation.

In the railroad cut, north of Mr. John T. Bell's, two or three of these white and purple clay beds are exposed, and south of him similar clays show along the dirt road. In many instances it is difficult to say whether the clays belong to the Clayton formation or to the Lafayette overlying it, and in like manner some of the cross-bedded sands can hardly be placed with absolute precision. From the circumstance that the clays are so persistent in their occurrence along the belt of country underlaid by the Clayton, we should be inclined to consider them as Tertiary, and so also with the sands, which may in some cases at least be *residua* of the Tertiary strata. The soils over this terrane are as a rule of superior quality, no doubt on account of the effect exercised by the calcareous beds of the Tertiary. The characteristic soil of this section is a red or brown sandy loam, which supports a growth of upland oaks, hickories and long leaf pine. This class of lands extends from Clayton about down to Louisville, beyond which comes the region formed by the Nanafalia series, the beds intervening between these in the western part of the state being very thin if not absent altogether here.

The Tertiary strata exposed in the gullies about Louisville are an indurated greensand filled with the moulds of shells,

and a blue clay underneath it. These are probably members of the Clayton division, but none of the shells could be determined.

The *Nanafalia* series of strata being generally sandy do not make any decided impression upon the soils of the overlying Lafayette but an occasional bowlder of disintegration of the indurated ledges of what we have called the *pseudo-buhrstone*, attests the horizon. To the west and southwest of Clayton, the red lime lands extend far down the valley of Pea River within five or six miles of the Dale county line as shown by Mr. Langdon, while adjacent to them and outcropping upon the summits of the hills in overlaps are the strata of the Nanafalia.

As a rule the soils over the Nanafalia are sandy, and the long leaf pine the characteristic tree. Upon the level divides between the streams, and often upon level areas at lower altitudes, sands prevail among the surface strata to the extent of producing barrens upon which very little except the turkey, upland willow and stunted black jack oaks can grow. In most cases these sands belong to the Ozark horizon, though sometimes the Lafayette exhibits exceedingly sandy phases.

Below Blue Springs the strata of the underlying Tertiary by inference belong to the *Tuscahoma* division of the Lignitic, but there are no outcrops which can be definitely referred to that horizon, which would in any event underlie but a small proportion of the area of the county.

Of the later (Post Tertiary) formations much has already been said in connection with the Cretaceous and Tertiary. Over the whole county there has been spread a mantle of pebbles, sands and red loam of *Lafayette* age, which originally covered the elevations as well as valleys. Remnants of this mantle are yet to be seen upon most of the divides, sometimes forming the surface over very considerable areas, and making the soils. These same materials with the same structure and order of succession are also found upon a

The Clayton formation furnishes a hard almost crystalline limestone in places sufficiently pure to be burned for lime, and nearly everywhere good for building purposes. In the same formation there are thick beds of indurated clays that should find some industrial application, and over a great part of the territory the beds of white and purple plastic clays interstratified with the sands which certainly might well be used in pottery and for tile making, as well as for certain classes of brick.

In the Ripley formation there are beds of greensand interstratified with the blue marls and calcareous sands, which contain notable quantity of phosphate of lime and which should be used on the adjoining fields. These phosphatic marls would not bear the cost of long transportation any more than do the marls of New Jersey which they resemble in all respects, but like those they would unquestionably work a revolution in agriculture if only persistently and systematically used. One such greensand marl occurs for instance in the banks of the river on the place of Mr. Jas. M. Blackman some miles above Eufaula.

BULLOCK COUNTY.

The outcrops of the *Rotten Limestone* extend up Line, McCulloch's, Town, Cupiah Hatchee and Prairie creeks, to the foot of Chunnenugga ridge, where they all take their rise. Thus the northwestern part of the county is characterized by the prevalence of the black prairie soils, and the gently undulating topography peculiar to this division. Between the streams the ridges are capped with the sandy strata either of the Ripley or the Lafayette and in many cases by both. The Chunnenugga ridge may hence be considered as the dividing line between the prairie lands and the sandy lands. Where the sandy strata either of the Ripley or the Lafayette adjoin the calcareous clays of the Rotten Limestone an intermediate soil is the result, "the post oak prairie soil," of yellowish or reddish color and unlike the regular prairies, supporting a fine growth of post oaks.

The strata of the *Ripley* here consists of massive clays usually more or less calcareous, containing often white concretions of lime, and alternating with bluish calcareous sands or sandy clays commonly termed "blue marl". In these are found the beautifully preserved fossil shells which have rendered this section famous among the geologists.

A marked topographic feature of Bullock county is the Chunnenugga Ridge, which for a good many miles in this county and also in Montgomery divides the waters flowing into the Gulf by way of the Alabama river, and those going more directly by way of the Chattahoochee, Pea river, and Conecuh. The basis of this ridge is made by the micaceous, sandy marls of the Ripley, which are covered with a considerable thickness of the Lafayette sands and loams. Towards the north the slope of this ridge is generally rather abrupt while in the other direction it is so gradual as to be at times nearly imperceptible. Towards the north denudation has been more active apparently and the covering of Lafayette materials has been more generally removed, or at least thinned down, so as to bring today the Cretaceous strata. This is particularly the case along the tributaries of Town creek which head near the foot of the ridge. In these lowlands the soils are rather clayey being derived from the calcareous clays of the Ripley, and a little further northward from those of the Rotten Limestone. It is often very difficult to determine where the Rotten Limestone ends and the Ripley marl begins, for some of the calcareous clays of the latter very closely resemble some of the phases of the former, and the derived soils are likewise very similar. The ridge is caused by the denudation of the land on the two sides of a water-shed and there seems to be no reason for thinking that it is due to any warping of the underlying strata.

The soils to the northward of the Ridge are of three general types: (1), those derived from the disintegration of the calcareous Cretaceous beds, in which they are the usual, black, stiff prairie soils: (2), Those resulting from admixtures

ilar materials is present in the hill upon which Hamner Hall, the Capitol, and many of the residences are situated, but they are not exposed in a single continuous section. Where the M. & E. R. R. cuts through the hill near the cemetery, these sands are well exposed again. Here as elsewhere they are seen to be capped with ten or fifteen feet thickness of red loam and pebbles of the Lafayette.

At the city of Montgomery this ridge is narrow, but it widens out eastward, being four or five miles in width about Mount Meigs, and of the nature of a level plateau, capped with the usual red loam and pebble beds of the Lafayette. This plateau, like so many others of the kind, has an elevation of about 400 feet above tide.*

The *Rotten Limestone* is encountered going southward from Montgomery immediately upon descending from the Eutaw sand ridge above mentioned, and continues in this direction to the foot of the hills upon which Strata is located. The section obtained by traversing the county along this line will give a fairly correct idea of the characters of the soil and of the topography of this division. Between Montgomery and Snowdoun the country is of the typical Rotten Limestone aspect, rolling, nearly level prairie, with 30 to 40 feet relief from summits to troughs. For the next five or six miles, down to McIntyre's, the surface is more broken, and the soil has a tinge of yellow or mulatto color, in place of the uniform black or dark gray of the prairies above.

*These plateaus occur in all parts of our coastal plain with any of the divisions either of the Tertiary or of the Cretaceous as substratum. Thus, the substratum is of Tuscaloosa age in Tuscaloosa and Pickens counties; Eutaw in Autauga and Montgomery; Rotten Limestone in Lowndes and Dallas; Ripley in Crenshaw, at Highland Home; Clayton at Clayton, in Barbour county; Naheola at Greenville, in Butler county; Nanafalia at Black's and Gullette's Bluff, in Wilcox, and at Lawrenceville in Henry; Tuscahoma at Newtown Academy, in Wilcox; Buhrstone at Cokersville in Monroe, and Abbeville, in Henry; White Limestone at Perdue Hill, Belleville and Monroeville, in Monroe; Grove Hill in Clarke, etc.

Post oaks set in along with short leaf pines, honey locust, elm, water oaks and hickories.

White irregular concretions of lime are abundant not only in this red soil but also southward to the limit of the calcareous region a few miles north of Argus. The post oak country is slightly higher than the regular black prairies, say ten or fifteen feet. In this section there are frequent ridges, capped with sand, rising at least 100 feet above the neighboring watercourses. Such ridges, when examined, are found to be due to a ledge of limestone filled with oyster shells (*gryphœas* and *exogyras*), and often pure enough to be burned for lime. From McIntyre's the country rises gradually to the foot hills of the Strata ridge, which is near the beginning of the Ripley strata. Crossing the country a little further towards the east, from Pine Level to Pike Road and thence to the railroad, mulatto lands are first crossed about eight or ten miles below Pike Road, in a belt four or five miles wide, and then the usual level black prairie lands to the railroad.

Southward of this belt of canebrake or black prairie lands sets in the territory of the *Ripley*, the general nature of which may be seen by the exposures along the road from Montgomery to Rutledge. After leaving the somewhat flat prairie and post oak lands of the Rotten Limestone, above mentioned, the country becomes hilly, with the upland oaks and hickories and short leaf pine as the timber, but the influence of the lime of the underlying Ripley sands is plainly seen in the vegetation, manner of growth, etc. A short distance north of Strata the hills show a grayish clay filled with white concretions of lime, with yellow sands above. Beyond Ramer Creek crossing similar gray clays with a few shells, with a capping of redloam, form low hills fifty feet or more in height. The sands and loam of these hills south of Ramer Creek are all highly micaceous, and are very similar to what may be seen in descending Chunnenugga ridge to-

der; but since this, as well as the other older formations of this part of the state, has been covered in comparatively recent times by beds of pebbles, sand and red loam of the Lafayette age, the underlying limestone rock is hidden over a very considerable portion of the county. Denuding agencies have removed these overlying beds in many places and laid bare the limestone rock. This, upon disintegration, yields the prairie soils which are so characteristic of the Rotten Limestone region. Most of the high watersheds between the chief streams are level plateaus on which a thick coating of pebbles and sands capped with a red clayey loam, overlies the Rotten Limestone. A good example of this sort of high plateau is that upon which Lowndesboro stands. It should also be added that within seven or eight miles of the Alabama River alluvial beds have been deposited upon the eroded surface of the Rotten Limestone, usually hiding it from view except in the banks of the river and of the larger creeks.

Ripley. The beds of this formation or division occupy a strip some five or six miles wide along the lower edge of the county. The great bulk of it is made up of micaceous and calcareous sands, but interstratified with them are ledges of harder materials, which are at times indurated calcareous sands, and at times a sandy phosphatic limestone.

This disposition of the two classes of strata produces, in the progress of denudation, a very uneven and rugged country; for the hard ledges protect the underlying softer beds from being entirely removed, and where cut through in places, the sides of the ravines are usually very steep and precipitous. Through all this region there are, in consequence, steep clayey and limy hills, timbered with red (Spanish), post and white oaks, dogwood, sweet and sour gum, ash, poplar and hickory, all draped with long moss. In the extreme lower part of the county and also in places on the divide between Big and Dry Cedar Creeks, the Nautilus rock of the Clayton or Midway group of the Tertiary caps many of the hills, thus bearing its part in the produc-

tion of a broken country. This part of the county, especially the southwestern corner where the Nautilus rock appears capping the Ripley sandy beds, is part of the Little Texas region of Butler, and is quite different in general appearance from any other portion of the state formed by these rocks.

The Ripley micaceous sands are also seen as outliers at a distance from the regular continuous outcrop of the formation, and of this character are the hills about Collirene, mentioned in Thornton's Appendix to Tuomey's Second Report, and also in Mr. Langdon's article above. Here the summit is a flat table land of pebbles and red loam of the Lafayette, some 15 feet thick. Below this a bed of conglomerate formed of grains of sand and casts of shells, cemented by phosphate of lime, 5 feet thick. From this down, there are some 100 feet or more of dark colored micaceous sands, of the usual Ripley character. A few miles south of Collirene still lower strata, consisting of calcareous clays holding concretions and shell casts in all respects like those occurring just south of Dayton, in Marengo county, are exposed in low places. In every direction from these Collirene hills the Ripley beds have been eroded, and the Rotten Limestone underlying them is exposed. Thus the calcareous clay of this last named formation is seen in the creek banks three miles east of Pleasant Hill; they are also seen between Bragg's Store and Collirene, after leaving the region of the Ripley group, which makes the country about the former place, we come upon the Rotten Limestone prairies before entering into the Ripley ground again about Collirene. So, also, in descending the hill towards the north the Rotten Limestone is soon reached. These Collirene hills occupy the very summit of the divide between the streams that flow northward into Soapstone and Old Town Creeks, eastward into Panther and other branches of Big Swamp Creek, southward into Dry Cedar, and westward into Mush Creek. Thus, by the erosion of all these streams and their tributaries, the Ripley strata have been removed

occurrences about Vinehill and to this description the reader is referred.

Below township 19 down to within two miles of the Alabama river the country is made of the *Eutaw* beds, which are yellowish crossbedded sands with clay partings along the lines of stratification or of false bedding, of the sands.

The weathering of these sands yields a sandy loam which is in many respects very similar to the loam of the Lafayette formation and at times difficult to distinguish from it. All this part of the county is hilly with intervals of level high plains between the water courses where they are sufficiently far apart. Upon these plateaus which have an elevation of four or five hundred feet above mean tide, the Eutaw strata are capped by the usual mantle of Lafayette consisting of a red loam at the top and sands and pebbles below. The country about Summerfield and between Selma and Summerfield presents all the characteristic features of the Eutaw division, until Valley Creek is crossed two miles from Selma, when the lime lands set in and continue to the sandy plain on which the town stands.

The city of Selma stands upon a third terrace of the Alabama river at an elevation of seventy-five feet or more above the mean water level. The bluff here shows about twenty-five feet of the sands, pebbles and loams of the *Lafayette* formation, resting upon about fifty feet of the chalky limestone. Most of the streams in the vicinity have their channels eroded down into the limestone, while the surface of the country is generally sandy from the Lafayete materials. The Selma terrace is two or three miles in width, and like all the terraces of its kind is very nearly level. Eastward of the city these lowermost beds of the Selma Chalk lap over the Eutaw sands to the north of the river plain for several miles, but generally in discontinuous patches. In these overlaps we find the phosphatic greensand marls above referred to, and more fully described in the chapter treating specially of the marls and phosphates.

Westward of Selma the lines between the divisions of the Cretaceous formations bend somewhat to the northward, so that all of the upper row of townships in that part of the county is underlaid by the Chalk, the weathering of which yields the soils and topography so often mentioned as characteristic of this formation. It must, however, be borne in mind that the Lafayette mantle has been spread over all this section and that the chalk soils prevail only where the Lafayette has been removed. In crossing the *Chalk formation* in going from Selma towards Prairie Bluff, one sees all the variations in the topography and soils of this division. Between Selma and Orrville by way of Cahaba the road being near the course of the river is nearly level and the limestone is covered more or less completely by the sandy strata of the Lafayette. Between Orrville and Liberty Hill the country is more broken, and along Bear Creek, the underlying limestone is frequently exposed. Liberty Hill is near the line between Selma Chalk and the Ripley sands and the soils in consequence, are of the transition type, "red post oak prairies," as they are generally called. Between Liberty Hill and Uniontown the way is over the prairie lands of the Chalk, with here and there an interruption in the shape of a strip of sandy land, due to a remnant of the Lafayette mantle.

It may be remarked, however, that the Lafayette capping is more continuous in the direction of the river than further northwest where, in the drainage area of the tributaries of Bogue Chitto in the western section of the county, there are many large tracts of the black prairie lands. Much of this kind of land is also to be seen along the line of the road from Selma to Marion Junction and thence to Marion on the one branch, and to Demopolis on the other.

On the opposite side of the river from Selma there is a wide Second Bottom plain, beyond which the Cretaceous strata come to the surface at intervals through the general covering of the Lafayette. In all this part of the Rotten

Limestone territory, the chalky limestone is exposed chiefly along the valleys of the numerous streams, while the divides are very generally high plateaus with the red loams of the Lafayette for the immediate surface, and with sands and water worn pebbles underlying them.

Pleasant Hill is situated upon one of these broad high plains, while the lowlands of Mush creek, of Cedar creek and their tributaries, exhibit all the phases of the prairie soils. The channels of these streams, as well as of the others in the various sections of the county, are cut down almost perpendicularly into the underlying limestone. Where the washings from the sandy uplands come in to temper the black prairie soils, the resulting intermixture makes some of the most desirable lands.

Along the Alabama river there are many fine exposures of the Rotten Limestone down nearly to the border of Wilcox. The most imposing of these bluffs are White Bluff and Elm Bluff, where as much as 125 feet of the rock of approximately uniform composition are shown.

At intervals through this formation occur beds of more clayey texture, filled with the shells chiefly of varieties of the oyster family, such as *Exogyra costata*, *Gryphæa vesicularis*, *Ostrea larva*, *Placuna scabra*, *Plicatula urticosa*, etc.

Below Dry Cedar creek and to the south of the river where it has a western course between Elm Bluff and Lexington, the strata of the *Ripley* division of the Cretaceous make the country down to the Wilcox line.

These strata while prevalently sandy, include calcareous clays, calcareous sands, and ledges of hard sandy limestone, to such a degree as to make a good part of the country of decided limy character. This may be appreciated, especially after rains along most of the roads traversing the lower townships of the county.

Carlowville and Richmond are situated upon a high level plateau four or five hundred feet above tide level. This pla-

teau, like so many others, has a capping of red loam underlaid by pebbles of the Lafayette formation, while the limestone ledges and calcareous sands of the Ripley are exposed at all points where erosion has cut through the overlying beds. Among the Ripley strata thus exposed, and especially about Richmond, is the bed of phosphatic greensand which has been used to some extent by Dr. Kyser and perhaps others.

About two miles southwest of Richmond we get the following section of the Ripley beds:

Section of Ripley Strata near Richmond.

1. Lafayette sands and pebbles.....5 feet.
2. Ledge of conglomerate, of reddish brown color, very hard, silicious and somewhat phosphatic.....2 feet.
3. Yellow micaceous sands.....15 feet.
4. Gray calcareous clay containing white lime concretions..20 feet.
5. Indurated ledge.....½ foot.
6. Micaceous sands .....5 feet.

Beyond this point through the Boykin settlement in the direction of Camden, the calcareous sands of the Bridgeport character form the whole country. These sands form stiff red soil which produces very good crops both of cotton and corn. The timber over much of this class of soil consists of white and post oaks, sweet gum, tulip tree, etc., all draped with long moss. Somewhat similar soils are seen also along the border of the Ripley and the Selma Chalk formations to the northward of Richmond, and they are due to the admixture of sand and calcareous clays. In this the red surface loam of the Lafayette takes at times an active part, though in some cases these red limy soils are more probably formed by the admixture of the sandy and calcareous beds of the Ripley alone. East of Minter Station, and southward of it to Wilcox county line, much of similar soil is met with.

Of the later formations in Dallas, the *Lafayette* is by far the most important, since it makes the surface of a very great

proportion of the high uplands, as well as of the level terrace of the river above the Second Bottom plain. This third terrace has already been spoken of as that on which Selma stands, and it occupies on the two sides of the river, in the aggregate, a very considerable area. The red loam soils upon the high dividing plateaus are almost all good farming lands and all in cultivation. While not so productive as the black prairie soils of the Selma Chalk, and the red lime soils of the Ripley, they are yet sufficiently fertile and are susceptible of indefinite improvement. They lie well, and the plains upon which they are found are particularly free from malaria.

The *Second Bottom* deposits of the Alabama river, lying just above overflow are of the usual kind. The surface material is a fine yellow loam more or less sandy in places, but forming some of the best of the farming lands. All this kind of soil is in cultivation, and has been from the first settlement of the country.

In the territory of the Selma Chalk the water is very commonly obtained from artesian borings, for where the limestone makes the surface the supply of surface waters is very limited. Where, however, sufficiently large areas within this territory are covered by the sands and pebbles of our Lafayette, there is no lack of water and of the very best quality.

WILCOX COUNTY.

The upper boundary of Wilcox county runs nearly northwest and southeast, following Chilatchee Creek on the west, and Pine Barren Creek on the east of the Alabama River. This boundary has about the same direction as the outcrops of the geological formations in this part of the state. Most of the county is made by Tertiary rocks, except a small strip of Cretaceous in the upper part.

Cretaceous.

The *Rotten Limestone* is found in the extreme northwestern corner of Wilcox county, but takes so little part in its geology as to need only a passing mention.

Ripley. The two boundary creeks above named, between Dallas and Wilcox, are also, especially Chilatchee, the lines between the Rotten Limestone and the Ripley groups of the Cretaceous. The outcrop of the Ripley formation runs southeast and forms a belt about six miles in width, including the following localities: Boiling Springs, Prairie Bluff, Rehobeth, Canton, Bridgeport, Gee's Bend, the Pine Barren region, Furman and Snow Hill. As stated in other places, the materials of the Ripley consist, in the main, of calcareous sands, but there are several thin beds or ledges of limestone, and interspersed through the sands are ledges of more calcareous nature, which have a tendency to indurate into tolerably hard rock. The sands are originally of a dark bluish or nearly black color, but when long exposed to the weather change into yellowish sands, which it would be difficult, without actual proof, to identify with the dark colored material. We have so often traced the passage of the dark colored into the yellowish sands, that there is no longer any doubt of their identity. This change of color comes from oxidation probably of the iron which the sands contain, and has its parallel in the sands of the celebrated Claiborne fossiliferous bed, the original color of which is a dark green, while at the bluff at Claiborne it is light yellow.

The Ripley formation in Wilcox, as in Marengo adjoining, forms a rather broken country, from the ease with which the sands are eroded, but where the hard, calcareous ledges are near the top they protect the underlying sands from washing, and give rise to the formation of steep knobs with flat tops.

The soils are mostly sandy, yet with sufficient admixture of lime to ensure fertility, as a rule. In some places these soils are rather stiff and limy, and somewhat resemble the

prairie soils. In this belt the so-called post oak prairies are not uncommon. The soil of these is a red clayey material with a good proportion of lime, and they are well seen most of the way from Boiling Springs to Plairie Bluff. At this latter place, there is a very characteristic section of the beds of the Ripley, which are, in the main, sandy; but among the sands are several ledges of limestone, and at the top of the bluff near the warehouse, a bed of phosphatic greensand, which well deserves the attention of farmers.

At many horizons in the Ripley there are great numbers of shells and shell casts or moulds, and the latter are usually composed of tolerably pure phosphate of lime. Many of these can be seen in the old warehouse yard at Prairie Bluff. Most of the indurated ledges which occur, especially in the lower part of the formation, are quite strongly impregnated with phosphate of lime. It is the phosphatic material from this formation which is now being worked at Coatopa in Sumter county, and doubtless a careful search in this county would be rewarded by the finding of a phosphatic limestone of quality and quantity which would make it possible to utilize.

The calcareous sands and impure limestone ledges of the Ripley are also well exposed in the high hills between Prairie Bluff and Rehobeth, in Gee's Bend, and at Bridgeport and Old Canton Landing. These occurrences have been detailed in the general section, to which the reader is referred. The bluffs at Old Canton Landing, and at Bridgeport, and at other landings below, to Prairie Bluff, all exhibit phases of the Ripley.

Across the river, at the mouth of Tear Up Creek, and, indeed, for some distance up it, we have the Ripley rocks exposed, as at Canton Landing. The uppermost beds of the Ripley may be seen at Palmer's Mill on Pine Barren Creek, six or eight miles north of Allenton, where they are in direct contact with the lowermost Tertiary. At Furman, or a mile north of it, there is a section embracing many feet of the Ripley strata, in which the position of the phosphatic green-

sand bed is clearly seen. All these occurrences are fully described in another place.

Tertiary.

Clayton or Midway group. The lowermost Tertiary rocks, consisting of a ledge of tolerably pure limestone, and a sandy limestone characterized by holding great numbers of large nautilus shells or casts, assume in Wilcox much larger proportions than in Marengo. The lowermost rock, a tolerably hard and pure limestone with numerous fossils, has been called, from the most abundant shell, the *Turritella* rock. It appears usually in rounded, bowlder-like masses, resembling some of the limestones of the Trenton formation of the Silurian. In the immediate vicinity of the outcrops of these rocks we always see a stiff, yellow, limy, clay soil, whose characters are, no doubt, dependent upon the rock. The *Nautilus rock*, on the other hand, usually appears as a gray, sandy limestone, which is disposed in rather thin ledges which break into blocks very readily. Upon disintegration it yields a loose, sandy soil, rich in lime, as is shown by the prevailing black color and the growth of cedars, which mark it everywhere. Other timber is also rather characteristic, such as chestnut, oak, sweet gum, iron wood and beech; but the main feature is the growth of cedar. In the eastern part of the county, about Barge's Mill, and thence up to Snow Hill, the country is formed by these two rocks, which rest upon the uppermost sands of the Cretaceous which are exposed in all the deep cuts. Here the lands which are derived from the disintegration of the Nautilus rock are called "cedar brake" lands, a very significant and descriptive name.

The Turritella rock on Pine Barren creek yields quite a number of fossils which, however, are not easy to obtain in very perfect state of preservation. *Venericardia planicosta*, and *Turritella Mortoni* may be recognized in most places, and in addition to these several new species of shells described in another part of this Report. As has been stated

elsewhere the general aspect of this and the Nautilus rock is decidedly Cretaceous, but the occurrence of the shells named seems to place them definitely with the Tertiary as its lowest member. At several points near and on Pine Barren creek the contact of the Tertiary limestone, with the Cretaceous sands can be seen and there appears to be complete conformity between the two.

Between Snow Hill and Monterey in Butler county, for seven or eight miles from the former place, these two rocks lie at the surface upon hills that form the western continuation of the "Little Texas" hills of Lowndes.

On account of the protection afforded by these strata these hills are left standing at considerable heights above the adjacent valleys which have been eroded out of the underlying Cretaceous sands. The country presents in consequence a very broken surface, which has a black, calcareous soil with a timber growth of large cedars mixed with some post and chestnut oaks, and hickory, ash, and hackberry, very closely resembling the prairie soils of the Canebrake belt of the Cretaceous. On nearing Monterey these strata sink below the next overlying Oak Hill strata which occupy the surface about the latitude of Pine Apple and eastward to the Butler line.

While these two lowest members of the Tertiary formation occupy a tolerably wide belt in the Eastern part of Wilcox, the belt narrows down towards the Alabama river, and west of it, assumes an unimportant role. The rocks are seen at the bluff of Midway Landing a short distance below Prairie Bluff, and are crossed along the lower road from Prairie Bluff to Clifton. Eastward of Wilcox they increase in thickness and become very important formations on the Chattahoochee, as may be seen from Mr. Langdon's descriptions.

Black Bluff or Sucarnoohee. This group of black clays underlying the "flatwoods" of Sumter and Marengo, extends into Wilcox with constantly diminishing thickness towards the east. West of the Alabama river there are

the usual 'Flatwoods,' but the northern edge of this belt is there exceedingly limy, making regular black prairie soils, as was noticed in Marengo county. In going from Henderson's Store near Prairie Bluff to Clifton, we pass first a belt of level black prairie country and across Dixon's creek get into the regular Flatwoods, with gray soil and post oak timber, in all respects similar to the flatwoods of Sumter. The black clays that constitute this formation, appear only at one place on the Alabama, viz., a short distance below Midway Landing. The terrible roads that connect Clifton with Prairie Bluff are, however, a good evidence of the existence of these clays in a tolerably wide belt here.

Eastward of the Alabama river, the materials of this formation undergo a very marked change. The lower beds become quite calcareous and give rise to black, clayey prairie soils, such as is seen just west of the river, and in part of Marengo. The upper measures of the group also become less clayey, and more sandy and at the same time much more calcareous, and instead of black clays we have over in eastern Wilcox at the top of this formation a series of light colored calcareous sands, and sandy limestone with phosphatic nodules. The black prairie soils derived from the lower 25 or 30 feet of the formation, are well seen just east of Camden at the foot of McNeil mountain, and thence eastward along Prairie Creek and past Allenton into Butler county.

The calcareous sands and sandy limestone, which, as above described, form the upper part of this group in Wilcox county and eastward, is first noticed on the road from Camden to Oak Hill, at Mr. Clarence Jones' place near the center of S. 4, T. 11, R. 9 E., embracing the beds from the Naheola marl down to the Wall rock, No. 14 of the Oak Hill section and No. 3 of the Grave Yard Hill Section. But one of the best exposures is nearer to Allenton on what is called the Graveyard Hill, a section of which has been given in the general part of this report, (page 189).

These strata give origin to a very characteristic soil in all this part of Wilcox, and in the adjacent parts of Butler. It is a somewhat sandy surface soil, with a sticky, heavy red or yellowish red clay subsoil. The timber growth is red, (Spanish) and white oak, sweet and sour gums, dogwood and short leaf pine, and in some localities, post oaks, water oaks and hickories. The soils of this kind form a strip of uplands, running almost across the county, at least from near Camden, into Butler, and situated between the foot of the Grampian Hills on the south and the strip of black prairie lands on the north. Occasionally, as on each side of Prairie creek, the prairie soils reach southward into this belt for some distance.

As we go eastward the strip of black prairie soils appears to diminish in width, while that of the red limy clay uplands increases correspondingly. Eastward of Allenton and in Butler county, there is a somewhat broken but very pleasing country formed by these beds, the alternations of soft, clayey, or shaly beds with harder calcareous ledges, in the natural processes of erosion produce clayey hills capped with low bluffs of sandy limestone. Towards the north this kind of country merges very gradually into black prairie lands resting on the lowermost beds of the group.

Naheola. The strata of this group are seen along the Alabama River from above Clifton down nearly to Coal Bluff, and consist, in the main, of sandy clays with a black fossiliferous sandy clay at the base of the formation, well shown at Matthews' Landing.

From Coal Bluff the outcrop of these strata turns abruptly towards the northeast, bringing them nearly up to Camden, and between that town and the foot of the Grampian Hills.

The best natural section of this group is at Oak Hill, a few miles south of Allenton. The fossiliferous bed has been seen, besides at Matthews' Landing, at the following places: On Clarence Jones' place east of Camden, S. 4 T. 11 R. 9

E; in an old field 3 miles west of Rosebud; at Oak Hill; in Dale's Branch, and at many localities near Allenton.

The other strata of the formation being sandy clays with no very characteristic features, make no decided impression upon the country, which is rolling, with sandy, but not infertile soils.

Nanafalia. The characteristic feature of this formation is the great prevalence of sandy beds, with beds of small oyster shells. These oyster beds may be traced all across the state to the Georgia line. Eastward of the Alabama River there is a great thickness of hard sandy strata containing shell casts.

These beds bear a close resemblance to the Buhrstone, and, like that rock, make high rocky hills. In Wilcox the Grampian Hills owe their prominence to the beds of this rock, and the continuation of these hills may also be seen in Butler.

West of the river this *pseudo-buhrstone* rock has not been observed, except near the river in the vicinity of Bethel, and the general characters of the formation are the same as we have described them in Marengo. This formation has an exceptionally great width across Wilcox, averaging some ten or twelve miles. This is partly due to the prevalence of the hard, buhrstone-like rocks, which, in resisting denudation, carry the upper line of outcrop far to the north of the general trend of the formations; but something of it is also probably due to a greater thickness of the strata, which may be referred to this age. Fine exposures of the oyster-bearing beds of the formation may be seen along the river at Black's and Gullette's Bluffs below Camden, and in the bluffs lying south of Pursley and Gravel Creeks. The *pseudo-buhrstone* rock finds its best exposure in the Grampian Hills.

West of the river, where these hard rocks are not found, the country made by the Nanafalia series is gently undulating, with somewhat sandy soils, which are, however, in most places, kept above the average in fertility by the action of the marl.

In the Grampian Hills even, the soils are not so poor as in the true buhrstone region, for the whole formation is characterized by the frequent occurrence of beds of greensand among the other strata. In the eastern edge of the county, below Pine Apple, this group narrows down very considerably, but in Butler it again widens out in its outcrop from north to south, and covers a belt of six or eight miles.

In coming in to Camden from Black's Bluff, we see a fine exposure of the rocks of this group in the hills south of Gravel Creek, and still better in those south of Pursley Creek.

In the Gravel Creek region, near the house of Major Tait, the Nanafalia marl bed is in almost immediate contact with a bed of lignite, which probably belongs to the Wood's Bluff series. This same position of the two formations may be seen near Black's Bluff at a spring, and on Mr. James Tait's plantation the Wood's Bluff marl is seen immediately touching the Nanafalia marl. In their proper positions, these two marls are separated by at least two hundred feet of strata, and they have been brought thus in direct contact by a fault or displacement, which we have named the Bethel Fault.

On the road from Newtown Academy to Camden we have a very complete view of the Nanafalia group in all its varieties.

The lower part of this region, just above the county line of Wilcox, is a typical short leaf pine upland, with a stiff, limy, clay soil derived from the disintegration of the calcareous and glauconitic clays of this group. The timber of these uplands, besides the short leaf pine, consists of maple, white, red (Spanish), and post oaks, sweet and sour gum, and hickories, all draped with long moss. In many places along this road the Tertiary rocks are covered with sands and pebbles of much later formation (Lafayette). Fatama is situated upon such a pebbly hill. Above Fatama we cross a belt of long leaf pine uplands consisting of sandy soil, with

numerous fragments of a claystone which very closely resembles a similar substance in the genuine buhrstone, except that it is, as a rule, full of shell casts.

Along the eastern road, from Newtown Academy to Camden, we pass very much the same series of outcrops, but the Grampian Hills are here narrower than they are to the westward. The disintegration of the rocks produces a great variety of soils. The more calcareous beds give a stiff, limy, clay soil, with short leaf pine, while the sandier portions yield soils that support the long leaf pine and its associates.

From this it will be seen that the soils of Wilcox below Camden are, at least half of them, stiff, limy soils of more than average fertility, and as the formations of the lower Tertiary and upper Cretaceous appearing above Camden, are also more or less strongly calcareous, a very considerable proportion of the soils over the whole county may be classed as limy soils.

Bell's Landing group.—Along the river the strata of this formation make the banks from Bell's Landing up to Yellow Bluff, this wide outcrop being due to a roll or undulation in the strata, which forms what we have called the Lower Peach Tree Anticlinal. These beds form yellow sandy loam soils, with short leaf pines and varieties of oaks for the timber, and the surface is gently rolling. The most characteristic occurrence of this type of country in Wilcox is west of the river to the northwest of Lower Peach Tree. East of the river the region underlaid by these strata is in the bend of the river opposite Lower Peach Tree and the Tertiary rocks do not show up very prominently, and do not affect soils and topography so markedly as they do at a greater distance from the river.

Wood's Bluff and Hatchetigbee.—These formations appear in Wilcox in two parts, viz., in the vicinity of Bethel, and extending thence southeastward across the river by Black's Bluff to the Grampian Hills, and again in their normal

place in the extreme southwestern corner of the county back of Lower Peach Tree.

The anomalous position of the first named outcrop is brought about by the undulation above spoken of and a fault or displacement of the strata, which we have named the Bethel Fault.

This fault or displacement has been followed by us from near Bethel across to the Grampian Hills beyond Gullette's Bluff, and by it the Nanafalia beds have been brought in contact with the Wood's Bluff. Between these two outcrops of the Wood's Bluff beds, these strata (Wood's Bluff and Hatchetigbee) have been denuded away and the underlying Bell's Landing strata form the surface as shown on the map. The map itself and the cross section through the fault and Anticlinal given elsewhere (p. 206), will sufficiently explain the structure. In all localities of its occurrence the Wood's Bluff group is unmistakable, the characteristic features being a greensand marl filled with shells and showing a tendency to form, by induration, bowlder-like masses of a sort of hard greenish limestone rock. This marl and the bowlders lie in the midst of clayey strata which give rise to steep hills with limy clay soils.

MARENGO COUNTY.

Like Sumter on the west, this county is formed by strata both of Cretaceous and of Tertiary age. A northwest and southeast diagonal across the county, just below Linden, would mark the line between the two.

Cretaceous.

The northernmost belt of this county is made up by the *Rotten Limestone* and by the upper strata of the same. The characteristic soils are similar to those mentioned under Sumter, and to those formed everywhere by this rock. In

the upper part of the county the black prairie soils prevail. Towards the southern border of the prairie region the limestone becomes usually much mixed with clay, and is full of fossils which are mostly members of the oyster family. Over most of the prairie country the Lafayette sands are wanting or present only in small patches. Where these sands mingle with the limy soil they bring about a number of modifications which form the basis of what are known as the "post-oak prairies," with red clayey soil and a growth of post oaks and short leaf pines.

In going from Faunsdale to Dayton a strip of such post oak prairie land is crossed about three miles north of Dayton. This would about mark the limit of the Rotten Limestone in this direction.

Ripley.—The next succeeding belt, lying between the prairies and the Flatwoods, is underlaid by the strata of the Ripley group, sandy calcareous beds, that do not impress themselves upon either soils or topography as forcibly as does the Rotten Limestone. The bulk of the Ripley beds consists of blue micaceous sands, which weather out to yellowish sands where exposed to the sun and free air. With these sands we find, at several horizons, thin beds of hard sandy limestone, containing fossils and casts of fossils, the casts being, as a rule, very rich in phosphate of lime. The micaceous sands give gently rolling country, with here and there little bluffs where the limestone stratum lies near the top and breaks off by being undermined, leaving nearly perpendicular faces. Over much of this region about Dayton, sands are found as surface beds, often in very considerable thickness. As the sands follow pretty closely the outcrop of the Ripley beds, it is fair to suppose that they are derived from them, though they are usually indistinguishable from similar sands of Lafayette origin. Be this as it may, the sands have undoubtedly been worked over and do not lie in undisturbed position in their original place. Occasionally

we find great beds of shells in these sands. Near Mr. Cap Sanders', below Dayton, there is a bed of such shells and shell casts, which are rich in phosphate of lime and might undoubtedly be profitably used as fertilizers.

While the bulk of this formation is a micaceous sand, there are admixtures of clay which give rise to pretty heavy soils, and these, where subjected to the influence of the weathering limestone beds, are lined into genuine marly soils, such as may be seen anywhere along the belt just south of Dayton.

In this, as in other parts of the state, with strata having a gentle dip towards the south, the steep slopes of the hills are always those looking towards the north, while the southern facing slopes are, as a rule, very gradual. Such is the case with the hills which rise just below the bottom lands of Chicksabogue. Next to these bottom lands there are numerous tall knobs capped by the yellow limestone, while the main body of the hills lies half a mile or so further to the south.

Linden is situated at the lower border of this division, and immediately adjoining the "Flatwoods."

Tertiary.

Clayton.—The lowermost beds which we have assigned to the Tertiary, consist of a limestone and a calcareous sandstone which have a close resemblance to the uppermost of the Ripley beds, above described, and which can scarcely be separated from them as they merge into each other. Thus south of Dayton, beyond Chicasabogue, we come upon territory where the caps of the elevations are of the Tertiary while the lower parts are of Cretaceous age.

This sandy limestone which we have just mentioned, is characterized by the presence of a large Nautilus shell in great numbers, and it has consequently been called by us the *Nautilus rock*. In some parts of the state it is used as hearthstones and for rough building purposes.

On the farm of Mr. C. C. Shields, below Dayton, in this rock, there have been found at times quantities of a black bituminous matter, a fossil resin somewhat resembling coal, or rather, hardened asphaltum. This substance burns very freely with much smoke, and leaves behind a very small amount of ash. It appears to occur not in continuous sheets as does coal, but in small isolated pockets which are soon worked out. Mr. Shields has taken the bituminous matter out of several such pockets in his farm.

The deposits of this substance which Mr. Shields worked out were of nearly circular outline and lenticular shape.

This material has been analyzed for me by Dr. Wm. B. Phillips with the following results which show that it is a fossil resin:

Fossil resin from near Dayton.

Proximate analysis.	
Volatile combustible matter	57.65
Fixed carbon	41.00
Ash	.15
Moisture	1.20
	100.00
Ultimate analysis.	
Carbon	63.88
Hydrogen	9.07
Oxygen (by difference)	20.21
Nitrogen	.37
Sulphur	5.12
Ash	.15
Moisture	1.20
	100 00

Black Bluff or Flatwoods.—Below the belt of sandy, hilly country made by the Ripley formation and the first of the Tertiary, comes a strip of "Post-oak flatwoods," some five or six miles wide. Towards the upper or northern edge of this belt, the soils are unlike the typical flatwoods soils, in being very black and limy, resembling those of the prairies, and formed either by the liming of the flatwoods clays by

the contiguous calcareous beds of the lowermost Tertiary and uppermost Cretaceous, or by disintegration of the lowermost beds of the black clay group itself, which here and towards the east are strongly calcareous. It is probable that both these causes operate to make the northern border of the flatwoods in Marengo and eastward, much more strongly impregnated with lime than the rest of the formation.

On going from Mr. C. C. Shields', S. 16, T. 15, R. 4 E. towards Shiloh the flatwoods are reached about three miles from his house, and at Mr. Bledsoe's we enter a strip of black limy soils, made as above suggested. This strip is about a mile wide where crossed along this road, and beyond it come the flatwoods soils of the usual type, yellowish gray clays timbered with post oaks and short leaf pines.

Further towards the west, Linden is situated on the northern border of this "flatwoods" region, which at this place is about 50 feet below the level of the ridge on which the town stands. The belt here also is about six miles wide, and has the usual soil and timber. The northern border of the flatwoods, is a hilly region made by the laminated clays of the next group.

Naheola.—As in Sumter county, the laminated clayey sands of the Naheola group are met with in the first hills south of the flatwoods belt. About six miles below Linden, the road ascends a long hill of dark gray laminated clays near the base, and reddish clays near the top. This difference in color is probably due to the difference in the degree of oxidation. The first summit of these hills is about 150 feet above the level of the flatwoods, but about three quarters of a mile beyond, we come to a still greater elevation, at least 50 feet higher, capped with red loam and pebbles of the Lafayette. From this summit the country slopes gradually down to the bottom lands of Beaver creek in which the Nanafalia marl is exposed.

On the Dayton and Shiloh road, we find a very similar state of things, the southern border of the flatwoods being a range of hills formed by the gray laminated sandy clay

of this division, and these hills here also slope gradually down toward Shiloh where the Nanafalia marl is seen in the banks of the streams.

Nanafalia. The materials of this group as stated heretofore, consist of sands and clays with many feet thickness of a shell marl, in the upper part, and a bed of lignite near the base, the whole thickness of the formation being feet of which four to seven are formed by the lignite, about 140 and about fifty to sixty by the marl bed. The greater part of the country which is formed by the outcrop of these beds has no very distinctive character. It is only where the influence of the marl is felt in the soil, that we have any noticeable marks of the formation. Thus, below Linden, after descending the Rembert Hills towards the south, we come into the bottom lands of Beaver creek which are marled by the Nanafalia beds, giving rich, limy clay soils. This marl bed crops out at various levels for several miles, but it does not seem to have very much influence upon the soils except where the conditions are favorable, as is the case in the bottoms and lowlands of the creeks. Upon the hills, the marl merely forms limy spots of no great extent, and of no particular agricultural value.

Many such outcrops may be seen along the road from the foot of the Rembert Hills towards Nanafalia. The marl is characterized by the presence of a species of small oyster. This marl may be seen for instance where the Linden-Nanafalia road crosses Double Creek, and along the hillside next further towards the north. The lignite shows in the banks of Landrum's creek near the Nanafalia Linden road, close to the 16 mile post from Linden. It comes to the surface at many places eastward by Shiloh, Hampden, etc. across the county, and is seen on the Alabama river at Coal Bluff.

The marl bed consists of sands in which *glauconite* or greensand forms a very important constituent, and imbedded in these are the oyster shells above named. These

oysters *(grpphœa thirsœ)* form nine-tenths of all the fossils of the bed, but at some localities, as at Nanafalia bluff on the Tombigbee, below the oyster bed are some greensands containing a very varied and rich assemblage of shells. The greensands on exposure to the weather are oxidized into brown iron ores, yellow ochres, and similar products, and in some of the Marengo localities tolerably fair beds of iron ore result from this cause. None of the hard Buhrstone-like rocks of the group have been noticed in Marengo. The country made by the formation is high pine and oak uplands.

Tuscaloosa or Bell's Landing. All the lower part of the county which is drained by Horse Creek, is made by the strata of this group, which as may be seen in the general section Part I. are mostly sandy; hence this part of the county shows nothing very characteristic, being as a rule, high, piney woods, as is the case with the lands formed by the same group in Choctaw.

By reason of an undulation in the Tertiary beds in this latitude, causing what we have called the *Lower Peach Tree Anticlinal*, the beds of this formation in Marengo occupy an exceptionally wide area of some twelve to fifteen miles. It is also nearly impossible to map correctly the areas formed by the Bell's Landing and the next succeeding or Wood's Bluff group, for the reason that they in many places occupy the same territory, the Wood's Bluff on the hills and the other in the lower grounds contiguous. Upon the high grounds not far from the river, the Tertiary beds are in part covered by the pebbles and loam of the Lafayette. Much is the case below Nanafalia on the Mobile road.

Lignites.—Beds of this substance occur in Marengo county at two horizons in very considerable thickness, viz., in the Nanafalia series near its base and in the Wood's Bluff series below the marl bed of that section.

The first of these is best seen on Landrum's creek near Nanafalia where a section is exposed about seven feet in thickness. An analysis of this has been made for me by Dr. Phillips with the results shown below.

This same bed crosses the county and has been observed at many points and comes to the Alabama river at Coal Bluff where the thickness exposed is about five feet.

The Wood's Bluff beds, for here are several close together, are seen in the river banks near Pickens' Landing, from which samples have been collected for analysis. The results of this analysis by Dr. Phillips I give below. These beds are encountered away from the river, at many places in the drainage area of Horse Creek.

Analyses of Marengo County Lignites.

	a.	b.
Volatile combustible matter	41.40	42.20
Fixed carbon	35.90	36.60
Ash	9.10	8.80
Moisture	13.60	12.40
Total	100.00	100.00
Sulphur		

(a.) Lignite from Landrum's creek near Nanafalia.
(b.) Lignite from Pickens' Landing.

SUMTER COUNTY.

A line drawn through this county northwest and southeast from the mouth of Sucarnochee river to the Mississippi line, would divide the county into two parts, the northern of which is made by Cretaceous, and the southern by Tertiary strata. These we shall describe from north to south in ascending geological order.

Cretaceous.

All the northern part of the county, above the latitude of Livingston, is made by the *Rotten Limestone* division of the Cretaceous. This is throughout a chalky limestone of varying degrees of purity, being pretty generally, however, mixed with a good deal of clay. In the neighborhood of Warsaw and westwards through Sherman, we see a belt of tolerably

pure limestone rock, which forms a rocky ridge, and upon weathering, this rock breaks up into rough irregularly-shaped fragments. The Rotten Limestone upon disintegration yields heavy calcareous clayey or marly soils, which are usually of black color where vegetable matter is not wanting. Throughout the "prairie" region, as it is commonly called, there are bald spots where the Rotten Limestone is exposed by the removal of the soil. In the lower part of this belt, near Livingston, the Limestone seems to contain an unusually large amount of phosphoric acid, as is seen in the analyses given on page 485. The Rotten Limestone soils are among the best in the state, and they give character to what is known as the Black Belt or Canebrake. In many parts the underlying Cretaceous rocks are covered with drifted sands and loam of the Lafayette and the soils are accordingly modified. From the disposition of the Lafayette sands and loam in this and adjoining counties, we are led to infer that the whole of the Rotten Limestone region has at some time been covered with a mantle of the later materials which have subsequently been in great measure removed by denudation except along the watersheds between the prominent streams. On all these watersheds accordingly, we find a covering of Lafayette of varying thickness occupying the summits and southern slopes which are exceedingly gentle, while the northern slopes are much more abrupt and show the naked limestone rocks nearly up to the summit. This feature of the topography may be noticed wherever in both our Cretaceous and Tertiary terranes, the streams flow approximately along the strike or outcrop of the rocks; the ridges between the streams have their steep and abrupt faces always looking towards the north, while the southern facing slopes are very gradual, and often appear nearly level. In the northern part of this county, between the river and Noxubee, we find a belt of these sandy soils which are occasionally loamy, extending from Sherman down, the width being some five miles at

the upper edge of the county and the length about ten.

Then between the Tombigbee and Sucarnochee, is another high ridge capped with sands, with steep slopes formed of the limestone rocks looking north, and gentle slopes covered with sands looking south. This ridge is one of the highest in the county. In the bend of the river about Belmont the surface soil on this ridge is excessively sandy, and these sandy hills come up nearly to Livingston. From these remarks the distribution of the various classes of soil may be accounted for. The pure limestone and prairie soils are to be looked for in the lower grounds, especially near the northward-facing slopes of the dividing ridges, while along the crests and for some distance down the southern slopes of these ridges, the sands cover to a greater or less degree the calcareous materials. Of course there are locally spots where the sands have been washed away leaving prairie soils exposed on the southern slopes, and places where these calcareous materials are still covered with sands on the northern slopes, but the general distribution is as above indicated. In all this region the soils are of two principal kinds, viz., the prairie soils derived from the disintegration of the limestone, a black clayey soil resting usually directly upon the limestone from which it has been derived; and the sandy soils, derived from the overlying Lafayette. Intermediate between these and formed by admixture of the two, are the *post-oak prairies*, whose soils are the loams of the Lafayette well limed or marled by the disintegrated limestone. Analyses of many of these soil varieties, as well as closer descriptions of them, may be found in my Agricultural Report, 1881–2.

Some of the most beautiful farming lands of the county are in the northeastern corner, in the neighborhood of Sherman on the Tombigbee slope, and thence along the course of the river towards Warsaw, Gainesville, and Epes. Similarly in the area of the Noxubee and Bodka creek drainage,

and further south within the drainage area of the Sucarnochee from Sumterville to Livingston, are many fine tracts of fertile prairie lands. In ante-bellum days most of these farms were held by wealthy planters.

The Ripley.—The sandy and calcareous strata of this group, as a rule, do not influence very strongly in the western part of the state, either the soils or the topography. Consequently we find in Sumter, below the latitude of Livingston, a narrow belt of country north of the Flatwoods, having sandy soils of no very distinctive character. The strata of this group hold usually a large number of fossil forms, mostly in the shape of shell casts or moulds, the petrifying material being usually very rich in phosphate of lime. These shell casts, and in some degree the limestone itself, have been utilized as a material for the manufacture of commercial fertilizers.

In the chapter of this report, dealing specially with the nature and distribution of the phosphatic materials of the state, the deposits of this Livingston, Coatopa belt have been pretty fully described. The Sucarnochee flows down about the direction of the outcrop of the strata of this formation and drains it. At Moscow, on the Tombigbee, we have a full and characteristic exposure of the rocks which make up the formation. The character of the river bluff from Moscow to the mouth of the Sucarnochee is fully given elsewhere, page 358, and illustrated with a plate, (XVIII).

Tertiary.

The Tertiary formations which appear in Sumter are the lower ones, up to the Nanafalia, as described in the general section.

Clayton.—The lowermost of the Tertiary beds are calcareous and resemble very strikingly in their lithological characters the uppermost of the Cretaceous. For this reason perhaps it has not yet been possible to discover, in their outcrop across Sumter county, any of these lowest Tertiary formations, and in going southward we pass from the terri-

tory of the Ripley or upper Cretaceous rocks directly into the Flatwoods.

Sucarnochee or Black Bluff group.—This has been named from Black Bluff in this county, where a section of some eighty feet is exposed. These black and dark brown clays form a soil which is very characteristic. It is a tough impervious clay soil, badly drained, and difficult to work, and appears in a belt running diagonally across the county and known as the "Post Oak Flatwoods." The growth in these flatwoods consists of small lanky post oaks, with some red, (Spanish) and black jack oaks, and short leaf pine, with an occasional hickory. The surface clay of the flatwoods is usually gray, speckled with red. It breaks up into small cuboidal pieces, which, so long as they remain wet, are tolerably hard and persistent, but on drying they crumble up into small fragments. Where exposed in railroad cuts and in wells, the flatwoods clay is seen to be a dark bluish or nearly black shaly clay, just as may be seen at Black Bluff, and along the river banks for several miles, to the lower limit of the county and even beyond. In most places, especially along the sides of the slight elevations in the flatwoods, may be seen small flattened fragments of limonite.

These flatwoods form a very well defined belt some five or six miles in width across Sumter, and while, as a rule, they form low flat country, in places low hills of crumbling black or brown clays, are quite characteristic, as may be seen west of York. Along the lower or southern edge of the flatwoods belt, we come into gray, sandy clays which form the transition to the next group of the Tertiary. The flatwoods soils are not deficient in the elements which constitute fertility and their bad repute from an agricultural point of view, is due mostly to physical causes, the toughness of the material and the bad drainage. The flatwood soils are all right, where they have a sufficient admixture of sand, which is often effected by small streams, bringing down sand from the hills bordering the flatwoods, and spreading it over the clays. Again, along the northern

border of the flatwoods belt we often find, in Sumter perhaps less than in some of the other counties eastward, areas of black, calcareous soils, like those of the prairies, due to the admixture of the calcareous matters of the underlying Tertiary rocks with these black, flatwoods, clays, as well as to the circumstance that these black clays become themselves more and more calcareous going eastward. Such soils are prevalent across the river in Marengo and will be again spoken of under that county.

Naheola. At the landing of this name on the river, we have the beginning of a series of sands and sandy clays that make up this group of our Tertiary, and which are seen along the river bluffs nearly down to Nanafalia landing. As these materials come to the surface across the county, they form a rather hilly belt with prevailing sandy soils. In many parts also occur beds of lignite, one horizon of such lignites being near the base of this group and close to the border of the flatwoods. About six miles west of York, on the land of Mrs. Petit, just beyond the outcrops, of the black clays, we find a lignite bed of considerable thickness. The same bed probably, is cut in a railroad excavation some miles below York. This lignite caught on fire and continued to burn for many years.

Crossing the flatwoods belt, below York or below Livingston, we find its southern border to be a line of hills, 150 to 200 feet above the general flatwoods level. These hills are formed by the gray clays and sands of the Naheola group, and from this elevation the country slopes very gently southward, with many interruptions of hill and vale, for six or eight miles, when we encounter another abrupt rise.

The characteristic timber of the sandy belt is pine, both long and short leaf, red, (Spanish) black jack, and post oak and the soils have usually a yellow loam subsoil often streaked with red, all resting upon the underlying Tertiary sands and sandy clays disposed in regular well defined beds or strata. Lignite is found also about the middle of this

section, in the low places about Bevill's store in Choctaw and northwestward about Gaston. In the neighborhood of Gaston there are heavy beds of sand which appear to be, in part at least, of late origin, but which may nevertheless have come from the disintegration of the underlying rocks. This great sand bed is of considerable extent but its limits have not been marked out by us.

Nanafalia.—The materials of this group have very little exposure in Sumter county. About five or six miles from Intercourse, on the Pushmataha road, and within half a mile of the Choctaw line, we come suddenly upon a high long leaf piney woods, with hard, light, gray soil and red loam subsoil. This is probably formed by the Nanafalia sandy clay, the country above this being oak uplands with short and long leaf pine and red loam soil and subsoil, in places quite sandy, resting upon, and derived from, the materials of the Naheola group. We have not seen any outcrop of the Nanafalia marl within the county limits, but it will, no doubt, be found exposed along some of the streams in the extreme southwestern corner of the county.

Of the agricultural value of this marl much has been said in the general section, and under those counties where it is best seen.

It is also probable that some of the strata of the Bell's Landing group may outcrop in the southwestern corner of the county, but they have not as yet been identified there.

CHOCTAW COUNTY.

The geological formations found in this county range from the Black Bluff group up to the White Limestone, and they crop out on the surface across the county diagonally, in belts running northwest and southeast. In the upper part of the county the general dip of the strata is about 30 feet to the mile towards the southwest; but in the lower or southeastern corner of the county we find an interruption in the continuity of this southwesterly dip, caused by the

Hatchetigbee anticlinal fold which brings the lower formations again to the surface.

The map shows the geographical limits of the several formations and the position of the anticlinal above named, and a figure, Plate XI, shows their undulations as seen in cross-section.

Sucarnoochee or Black Bluff.—The materials which make up this formation are mostly black, shaly clays, which, on exposure to the weather, disintegrate into a tough, clayey soil, which underlies the region known as the "Flatwoods." These clays are seen in the extreme northeastern corner of the county, and crop out along the river banks from the Sumter county line down to Naheola.

The Flatwoods area is thus seen to be a very limited one in this county, but it is correspondingly large in Sumter, under which section the characters of the Flatwoods soils and topography are more particularly described.

Naheola.—The strata which make up the Naheola group are mostly micaceous sands with thin clay partings. In the sands, which, along the river bank, are somewhat indurated, there are many bowlder-like, concretionary masses of still more indurated sands. Some of the beds are also slightly more coherent than others, and form projecting ledges along the bluffs of the river. These materials are seen along the river banks from Naheola to below the mouth of Beaver Creek, and show best at Tompkinsville. Kintabish Creek drains the area underlaid by the Naheola sands. This whole formation is almost devoid of fossiliferous beds, except the lowest, which occur at Naheola. The greater part of the region underlaid by this formation has sandy soils and is not very fertile. In places the sands are very deep, as at Gaston in the lower part of Sumter; but whether they result from the disintegration of the Tertiary beds or are, in part, of later origin and transported, it is not very easy to decide.

Where the surface sands are not too thick and the soils are evidently derived from the Tertiary beds, they are of

gray color and sandy, with a yellowish loamy subsoil, and have a vegetation consisting of long leaf pine associated with black jack, post and red (Spanish) oaks. There are other tracts which have the short leaf pine, but with the same character of soil and subsoil. Thin beds of lignite are to be seen in many places along the creeks and drains, as, for instance, near Pelham or Bevill's Store, near the N. W. corner of S. 18, T. 15, R. 1, W.

Large fragments of silicified wood are not uncommon in all this territory, and, in places, large, water-worn pebbles of quartzite and sandstone. Where this formation borders on the Flatwoods it rises into hills of considerable height, with steep slopes towards the north and very gentle slopes towards the south, down, at least, to Kintabish Creek, beyond which another abrupt rise is encountered.

Nanafalia.—In the preceding pages the characters of the materials which make up the Nanafalia formation are given in detail. These materials, which are mostly sandy, but hold great beds of shells of a species of oyster (*Gryphæa thirsæ*), usually make sandy soils, but where denudation has exposed the shell-bearing strata some very rich and fertile soils result. The Nanafalia beds stretch across Choctaw on both sides of Clear and Tickabum creeks, which exactly drain this area. The marl or shell bed may be seen at many points along these and Yantley Creek, as, near Tompkinsville, at the confluence of Yantley and Tickabum. The road from Tompkinsville to DeSotoville passes over soils derived mainly from this group, but showing evidences of having been worked over in some way by the waters of the creek; for we find at many places shells lying imbedded in what appear to be alluvial sands. At DeSotoville the country is made by the laminated sandy clays of this formation, and give rise to soils which are timbered with a long leaf pine growth. At DeSotoville itself, however, there is a very considerable proportion of oaks among the pines; but for several miles thence along the road to Butler regular piney woods prevail. Thus, while the Nanafalia group holds a

marl bed which is of great value for agricultural purposes, the prevailing character of the soils derived from the disintegration of the beds of the group, is that of the high piney woods. The marl bed may be seen at several points, e. g., on Clear Creek two and a half miles west of DeSotoville; at the confluence of Yantley and Tickabum Creeks; on the river at Nanafalia Landing, and at Eureka Lanking on the Choctaw county side, and thence for several miles down the river.

Too much cannot be said of the value of this marl upon the thin sandy lands of the county. Where it can be gotten without much expense it will no doubt greatly improve the lands wherever used. Many boat loads of the marl have been taken from Nanafalia and other places along the river, and carried down to Mobile and there used in the market gardens.

It should be remembered that the peculiar phase of the Nanafalia rocks which, in Wilcox County we have called the *pseudo-Buhrstone*, an indurated glauconitic sandstone, is not as yet known far west of the Alabama River, and has not been observed in Choctaw. All of the Nanafalia series in this county are more or less sandy and the resulting soils correspond, and even the marl makes in Choctaw nowhere that we have observed, such rich widely spread fertile soils as spring from it, where favorably exposed by denudation, as along Beaver Creek and eastward in Marengo, and along the northern branch of Flat Creek in Monroe.

Bell's Landing or Tuscahoma.—From the sections and detailed descriptions found in the preceding general section, Part I, it will be seen that the strata of this series are mostly sandy, with one or two intercalated sandy marls or shell beds. The sands are, when freshly exposed, of gray colors, becoming red on weathering, and disintegrating into reddish sandy loam soils which are difficult to distinguish from similar soils of the Lafayette further north. The marl beds of this series very rarely, if ever, exercise any decided influence upon the soils, and usually the only evidence which we have

of the vicinity of an outcrop of the marl upon the surface inland, is the finding of some of the characteristic shells commonly in very friable and much broken condition, scattered through the sandy loam. The Bell's Landing sands outcrop through Choctaw along a belt about three or four miles wide, the lower edge of which passes a mile or two north of Pushmataha and about the same north of Butler, and thence down to the river about opposite Pickens' Landing. Most of this belt, as might be easily imagined from the nature of the underlying material, has sandy loam soils of no great strength, and the prevailing timber is long leaf pine with varieties of oaks. Along with the long leaf pine we find also the short leaf in those places where the more clayey beds of the formation come to the surface. Yantley Creek and the upper waters of Tickabum flow pretty nearly in the general direction of this belt and drain it in the western part, while the small streams emptying into the river above and below Tucahoma drain the lower or southeastern part of this belt in Choctow. On the road from York to Pushmataha, the Bell's Landing marl is seen between Yantley and Tickabum Creeks in the southwestern corner of T. 15, R. 3, West. In going from Desotoville towards Butler we see that the lands formed by this series are favorable to the growth of the long leaf pine, especially along the upper or northern edge of the belt, while further down towards Bulter the short leaf comes in more abundantly and the admixture of oaks and hickory becomes greater, which shows that the lower beds of the group are, as a rule, rather more sandy than the upper, which pass gradually into the clayey materials of the overlying Wood's Bluff and Hatchetigbee groups. As we approach Butler along the road above mentioned, and within a mile of that town, in all the washes by the roadside there are exposed reddish crumbling clays breaking up into cuboidal blocks, and yielding a heavy clay soil which makes traveling in wet weather the reverse of easy. These probably belong to the Wood's Bluff and Hatchetigbee groups and are thus thrown a little north of

their regular position by reason of the topography of the country, the region north of Butler along this road, being pretty high and hilly. The same remarks will apply to Pushmataha, for about a mile before coming into that place from the north, we encounter the same reddish crumbly clays breaking up into small cuboidal fragments and finally breaking down into a heavy clay soil. These fragments of clay show very clearly the gradual transition from gray to red upon exposure to the sun and weather; for when freshly broken off they are of a gray color, but after short exposure become coated with reddish films and after longer time become of red color throughout, or have merely a gray central nucleus. As before stated, I think these clays come from Wood's Bluff and the Hatchetigbee groups, but they may be a more clayey modification of the Bell's Landing series, i. e. more clayey than is usually the case in the counties lying to the east of Choctaw.

Agriculturally, the Bell's Landing group is a pine upland forming series, for long leaf and short leaf pine uplands of identical character with these of Choctaw may be easily traced continuous across the country eastward through Marengo, the southwestern part of Wilcox, and into Monroe.

The Bell's Landing rocks make the banks of the river at intervals from Barney's upper Landing down nearly to Pickens' Landing, the best exposures of the marl bed being at Tuscahoma, (at low water), at Turner's Ferry, and at Barney's.

Along this stretch of the river we can very easily see undulations in the strata by which the sands of this series are kept at the surface over a wider area than they would normally occupy with the usual dip of thirty feet to the mile.

Wood's Bluff and Hatchetigbee.—As compared with the preceding series, these two are clayey formations, as may Part I, be seen from the general sections and descriptions, where the Wood's Bluff or Bashi marl is shown as occupying the middle part of a great series of clayey beds. On account of the prevailing clayey character of the great pro-

portion of these beds the soils to which they give rise are, as a rule, clayey and fertile, especially where the marl bed comes to the surface and enriches the soil. In many places these soils are called prairie or "lime hills" soils, as eastward of Choctaw Corner in Clarke county. These two formations in their outcrop form a belt about four miles wide lying immediately to the north of the line of high hills of aluminous and sandstone rocks which make so conspicuous a feature of the landscape just south of Butler and Pushmataha. As I have already stated, the clayey soils which are encountered just to the north of these two towns, are based upon the clays of this group which lie below the marl bed while those lying above it are commonly seen on the slopes of the hills above mentioned. Just below Butler for instance, the greater part of the first ascent of the hills is over the Hatchetigbee clays.

The head waters of Tickabum creek and the main course of Wahalak drain this area in Choctaw, the last named creek flowing along approximately parallel with the belt formed by these formations. Two features characterize this group not only in Choctaw but elsewhere, viz., the marl bed and the seams of lignite. The marl bed is some ten to fifteen feet in thickness and the materials are greensand and shells without any great proportion of phosphatic matter, but a large amount of carbonate of lime, so that the value of the bed depends upon the calcareous matter and the greensand. It is a question however, whether the greensand presents any available material for plant food. The Wood's Bluff marl may be seen in Rabbit creek at a mill some three miles south of Pushmataha on the road to Isney, then again in most of the ravines and low places about Butler and down Wahalak to the river. Of course these are only a few of the many localities where the marl may be found. It is always just north of the foothills of the mountain above mentioned. As to the agricultural value of this marl, it may be said that it is likely to improve the

soils wherever a calcareous manure is wanted. Experiments have been tried by O. C. Ulmer in Butler and by others, but we have only to observe the natural growth of those portions of the country where the soils are affected by the washings from this marl bed in order to form an idea of its value. In such localities we find beech, hickory, white oak, sweet gum, ash, red (Syanish) oak, poplar, holly, sour gum, cucumber tree, and some short leaf and spruce pines. As a rule, these trees in the marl region are draped with long moss. Such timber sufficiently indicates the character of the soil. As above stated, the upper road to Bladen Springs ascends the "mountain" a few miles below Butler, but the lower road skirts along the foot hills of this mountain till the mountain is ascended near Coppersaw. Here, as elsewhere, the first ascent of these hills is over the clays of the Hatchetigbee group. In coming from McCarthy's Ferry up towards Coppersaw, the lower part of the hills is formed by the Hatchetigbee clays which also form the bluff below the ferry, while the summit of the mountain is made by the rocks of the Buhrstone. In the preceding general part we have given a number of sections and detailed descriptions which will show sufficiently well the relations of all these beds to one another and to the over and underlying rocks.

There is no marl bed in the Alabama Tertiary which is so easily recognized and traced across the country by its outcrops, as the Wood's Bluff or Bashi marl. There is none which more surely indicates indicates its presence by its effects upon the soil than this. It has been followed continuously as far eastward at least as Elba in Coffee county, and always with the same general characters. In the clays lying below the marl bed, we always find several thin beds of lignite.

As analysis of the Wood's Bluff marl from Mr. Hendrick's near Butler, in S. 26, T. 13, R. 3 W. shows the following composition:

Analysis of Wood's Bluff marl from Hendrick's near Butler.

Insoluble matter	62.005	67.838
Soluble silica	2,833	
Potash		1.026
Soda		0.085
Lime		13.757
Magnesia		0.616
Br. oxide of Manganese		0.029
Peroxide of iron		4.286
Alumina		0.083
Phosphoric acid		0.161
Sulphuric acid		0.106
Carbonic acid		10.983
Water and organic matter		1.393
		100.363

Besides the area of outcrop of the Hatchetigbee and Wood's Bluff formations above described, there is another in the southeastern corner of the county as shown by the map. In this area the Hatchetigbee clays after passing beneath the surface just south of Butler, emerge again in consequence of an uplift which forms what we have called the Hatchetigbee Anticlinal. An anticlinal is an uplifted part of the earth's crust from the central ilne of which, the strata dip in opposite directions. The central line of this Hatchetigbee anticlinal extends from Hatchetigbee bluff on the river northwestward through Bladen Springs and beyond for several miles.

From this crest line, or axis, the strata dip towards the northeast on the one side and towards the southwest on the other. The dip is not easily recognized by the eye, and we can ascertain it only by observations at a number of localities. The Hatchetigbee clays being more or less pyritous everywhere, give rise to a great number of sulphur springs. The most noted of these are the Bladen Springs and Cullom Springs. Where these pyritous sands and clays are exposed to the weather they give rise also to the formation of sulphuric acid and sulphates of iron and alumina, etc., which are contained in the well known Acid Iron Earth,

which, however, is taken from similar materials occurring in the White Limestone. An anticlinal is necessarily, from its mode of formation, primarily an elevation of the earth's crust, but, as a rule, subsequent denudation has either leveled off the crest of the elevation or, in many cases, has even removed the central part or crest of the uplift more than the sides. This is the case about Bladen Springs, for the Buhrstone forms hills about the Springs, while the Hatchetigbee materials lie rather low in a depression. This anticlinal, which extends some distance over into Clarke county, is some forty miles long from one extremity of the Claiborne beds to the other, but it is carried in the White Limestone a much greater distance, i. e., into Mississippi on the one side and entirely across Clarke county into Monroe on the other.

The further details of this anticlinal may be found in the general section of this report and need not be repeated here. The borings at Bladen Springs begin in the Hatchetigbee clays at the top of the Anticlinal and have penetrated the whole of the underlying Tertiary beds above described, and have gone some distance into the Cretaceous strata. Its position in the geological section of the county may be seen from the diagram in Plate XXVIII.

Buhrstone.—This name has been applied to a series of sandy and aluminous strata over 300 feet in thickness, which are, as a rule, tolerably hard and resistant rocks, which, in consequence, form a range of hills or mountains extending across Choctaw from northwest to southeast, the upper or northern limit being a few miles south of Pushmataha, and of Butler, and along the river just back of McCarthy's ferry. Westward of Choctaw, in Mississippi, these hills assume still greater proportions in Lauderdale and Neshoba counties, while in the other direction they extend across the northern part of Clarke and Monroe into Butler. Beyond Butler they are not so conspicuous in elevation but may still be traced across to Georgia and into South Carolina.

As above stated, the Burhstone rocks form mountains or hills everywhere. In many places these are called "chalk hills" from the occurrence in them of a somewhat indurated white clay which is easily cut like chalk. Of true chalk (carbonate of lime), there is, so far as I know, no trace in this whole formation.* Near the base of the Buhrstone and also near the upper measures of it, are some beds of a silicious sandstone which are almost a quartzite. This rock has in past times been used by the Indians for their arrow points, and thousands of these may be picked up in Choctaw and Clarke counties. It is a white quartzose material with lead gray spots all through it, and it is very easily recogniaed. One locality, where it may be seen by the roadside, is a few miles above Bladen Springs on the Butler road. The country formed by the Buhrstone rocks is rugged and hilly and the soils exceedingly sandy and poor. The prevailing timber is the long leaf pine and its associates. Where the soil is unusually sandy the narrow leaf and forked leaf black jacks, or upland willow and turkey oaks, are characteristic, and where the surface soil is very thin, and the rocks lie near the surface, the vegetation is chiefly stunted black jack oak.

Another material of frequent occurrence among the rocks of the Buhrstone is a sandy aluminous rock which is everywhere used in the construction of chimneys, from Choctaw county across to Henry. Another is a compact fine grained clay, indurated into a pretty hard rock, which breaks up on thorough drying into pieces with curved surfaces and sharp edges. I can see no reason why this may not some day be utilized as a fire proof material.

This material was made into a brick and tested in the furnaces at Bessemer by Mr. Geo. E. Carlyle. The brick stood the heat without being at all melted. Its low specific gravity

*Much of the light porous rock of this kind is of the nature of true *tripoli*, i. e., the silicious analogue of chalk.

however, will probably stand in the way of its being utilized extensively. An analysis of it was made for me by Dr. Wm. B. Phillips with the following result:

"Clay" from Choctaw County, near Coppersaw.

Silica	86.30
Alumina	5.12
Oxide of iron	1.46
Lime	.46
Water and volatile	6.60
Total	100.08

It will be seen that this material is not a true clay, being too high in silica, but from examinations since made, it is known to be in great part made up of the silicious shells of diatoms, and of the nature of tripoli.

As might be anticipated these mountains are noted for their wild and rugged topography, and their sparse population. They are the haunts of deer and other game. Perhaps the most broken part of this territory in Choctaw is near the Mississippi line southwest of Pushmataha. In the western part of the county the Buhrstone outcrop is wider than elsewhere, approaching ten miles in width, from which it narrows down to two or three miles at the river. The Buhrstone is the only member of our Tertiary which has hard weather resisting rocks, excepting certain indurated greensand beds of the Nanafalia group in Wilcox, which we have called the *pseudo-buhrstone*, and which has its greatest development in the Grampian Hills.

Besides this northern regular belt of the Buhrstone we find another outcropping of the same rocks around the Hatchetigbee Anticlinal in the southern part of the county. The map will show their distribution in this section. They come to the river on the upper side of the anticlinal at the Bladen Landing and on the lower, near the Hatchetigbee bluff in Washington county. They are encountered in

going either north or south from Bladen Springs, and also in going westward.

The Claiborne. This formation, as will be seen by reference to the general section, is made up of sandy calcareous beds with a very considerable admixture of shells, considerable among which is an oyster (*O. sellæformis*) which often attains a large size. Many of these beds also hold a very large percentage of greensand. The most persistent and characteristic feature of the marl bed of this group is the oyster mentioned, which is found distributed through a vertical thickness of perhaps fifty feet of strata. About the only parallel to this may be seen in a small shell of the oyster family (*gryphæa thirsæ*), which characterizes the Nanafalia marl. At intervals through the sands of this formation, which are some 150 feet thick, are indurated beds held together by calcareous matter. Where the Claiborne sands form bluffs along the rivers and creeks these indurated portions form projecting ledges, as they offer more resistance to weathering than the sands. The country made by the Claiborne formation is usually gently undulating and much broken, the soils are mostly sandy and the timber long leaf pine and its associates, but where the shell beds of the formation or the more calcareous parts of it come to the surface, especially where there is some clay in the subsoil, they give rise to what are called in the county *piny woods prairie* soils, i. e. red limy clay spots usually occurring in the midst of piny woods, and very noticeable in contrast to the usual gray sandy soils of these woods. The timber of these prairie spots in the piny woods, consists of long leaf pine, red (Spanish), post, and white oak, with an underbrush of black gum and post oaks, and in the low places, large poplars.

In other places where there is less clay in the subsoil, the mingling of the Claiborne beds with the surface soils produce what has been well termed by O. C. Ulmer, of Butler, "Lime sands." The Claiborne formation can be about as easily recognized by the prairie or limy spots in the piny

woods as by an outcrop of the shell marl. The map will show two outcrops of this formation across Butler, the first is the regular outcrop lying just south of the Buhrstone hills above described, and extending from just north of Nicholson's Store, by Lusk and Womack Hill to the river. The other runs as a border all around the Buhrstone outcrops of the Hatchigbee anticlinal. The strata of this upper belt sink with a gentle dip southwards and come up again on the northern edge of the anticlinal leaving a long, narrow and shallow trough between. This trough is occupied by a few feet thickness of the overlying White Limestone as will be explained below. That the two Claiborne outcrops are continuous may be demonstrated at many points along Oaktuppah and other creeks which have cut through the overlying white Limestone and exposed the Claiborne beds below.

In the upper belt we find good exposures of the Claiborne sands and shell beds on Billy's Creek, S. 7, T. 11, R. 4 West, and also in S. 6, and again near Mr. Johnson Allen's in sections 36 and 25 of T. 12, R. 5 West; and also in sections 23 same township.

Also near Mr. George Bonner's on Oaktuppah in S. 22, T. 11, R. 4 W; and near Mr. Calvin Oates' on Bogue Loosa, in S. 20, T. 11, R. 3 W.

On Surveyor's Creek in S. 36, T. 11, R. 3, we have a good exposure of this formation in a bluff, and at many points between this and the last named locality the red limy clays interspersed through the piney woods, show the existence of the marl below the surface. So also north of Womack Hill, we have similar evidence of the presence of this formation. The outcrop and other signs of this formation in the belt around the Hatchetigbee anticlinal are almost too numerous to be specially named, but many of the localities have been given above in the general section, Part I, which may be consulted. At Coffeeville Landing on the Clarke county side, there is a typical exposure in the river bluffs, as well as in the banks above Coffeeville

wherever the Tertiary rocks are not hidden by the loose surface sands. At Bladen Landing, however, owing to a bend in the river, the Buhrstone forms the banks. At Old Barryton Mill on Oaktuppah, there is a fine show of this marl as also at the bridge over Souilpa on the Bladen and Butler road. At these two places the greensand is conspicuous and abundant, as are also the oyster shells. All around the northwest end of the anticlinal we find evidence of the Claiborne in the red, limy clays in the piny woods and in the outcrops of the marl beds in the banks of the creeks. Similarly along its southwestern border west of Bladen Springs, on the road to Isney. Here the transition from the Buhrstone to the Claiborne areas is very clearly noticed not simply in the rocks but also in the timber. Over the Buhrstone, this timber is chiefly long leaf pine with not much underbush, and the country is hilly. Beyond the five mile post from Bladen, the timber growth changes, and a very considerable admixture of varieties of oaks is found along with the pines, which are themselves both the short and the long leaf species. These Claiborne beds underlie the country along this road, as far as S. 15, T. 9, R. 5, where the first of the White Limestone is encountered. In S. 14 of the same township, near Jordan's Mill a very good exposure of the marl bed may be seen. Another outcrop of this marl occurs at Shoemaker's mill. This southern belt of the Claiborne runs southeast into Washington to the river just above St. Stephen's and thence into Clarke, as will be described under that county.

White Limestone.—This group in Alabama, as well as in Mississippi, can be readily subdivided into two parts, the lower of which, some 80 feet in thickness, consists of a clayey limestone, which, on disintegrating, gives rise to black, clayey, calcareous soils, very closely resembling those of the Black Belt of the Cretaceous. The country which is made by this lower part of the White Limestone is apt to be very much broken and cut up by washes into very steep, sharp hills, upon which are the prairie or limy soils.

Through all this region the "Lime Hills," as they are called, are quite characteristic. In some parts, where denudation has done less, there are wide and comparatively level prairie tracts. Such is particularly the case to the west of the end of the Hatchetigbee anticlinal. The upper part of the White Limestone, as a rule, has comparatively little influence upon either soils or topography. The country which is underlaid by it is commonly piny woods, with an occasional limesink to show the presence of the limestone below. The lower of these two subdivisions corresponds with the Jackson group of Mississippi, and an upper, with the Vicksburg.

From what has been said above, the distribution of these materials in Choctaw county will be readily understood. We find, first, a very narrow belt lying in the trough of the Claiborne sands, between the Hatchetigbee anticlinal and the "Mountain." This narrow belt holds only the lower part of the division and often only a few feet in thickness of it, while in many places the creeks have denuded the whole of it away and exposed the Claiborne sands across the entire trough. Nearest the river, the first area of this kind is to be seen at and near Womack's Hill, where the peculiar limy hills and outcrops of fossiliferous limestone may be observed. It is in this formation that the bones of the extinct whale (*Zeuglodon cetoides*) are always to be found; and besides these, sharks' teeth, bones of fishes, shells and other fossils are abundant. The outcrop of prairie lands at Womack Hill is only about three or four hundred yards across, and extends westward about two miles. Then follows a gap, and then another small area of about the same width and a mile long, in Mrs. Nix's field. In Mr. Moseley's and Mrs. Lassiter's farms the uppermost stratum appears to be a ledge of tolerably firm limestone weathering into rounded masses which contain numbers of fossils. Beneath this harder rock there are calcareous clays which also contain most of the fossils above named. These clays form the prairie soils above spoken of.

Beyond Mrs. Nix's, towards the west, the prairie spots are on the south side of Okatuppah on Dr. Gilbert's old place, and between him and Mr. Trice. From this they extend out to Kaiser Hill and merge into the wide prairie tract which includes Nicholson's store, and passes around the end of the anticlinal in a wide belt, extending from Nicholson's Store to five or six miles south of Isney, and increases to a width, along the Mississippi line, of nearly eighteen miles. From Isney the belt of prairie soils formed by the lower or Jackson division of the White Limestone, passes around the southeastern side of the anticlinal into Washington county. The prairie soils and lime hills here form a somewhat narrow belt, about five miles wide, narrowing to two or three in Washington county.

The soils of the prairies and lime hills are of four principal kinds: 1st. A black, loose, limy soil, crumbling easily between the fingers. This is commonly known as shell prairie soil, and it is timbered with dogwood, white and black oaks, ash, short leaf pine and buckeye. This is one of the best of the soils, and rarely fails to bring good crops. 2d. A black, stiff, waxy, prairie soil, difficult to cultivate, but fertile. 3rd. A red or chocolate colored, stiff, waxy soil, also difficult to cultivate, and, 4th. A stiff, gray clay which generally rests directly upon the limestone from which it has evidently been derived. The three last named are the calcareous clays, with greater or less admixture of vegetable matter, while the first is the real soil, containing enough of sand to make it loose and enough of vegetable matter to give it the characteristic black color. West of the end of the anticlinal we have the largest area of the prairie soils in Choctaw. This exceptional width is easily explained when we consider the uplift of the Hatchetigbee anticlinal. In all this area the underlying rocks are not pushed up so far as to come to the surface, but far enough to make the White Limestone the surface rock over a width of fifteen to eighteen miles. The same thing may be seen at the other end of the anticlinal, in Clarke county.

Where the prairie soils are continuously cultivated they do not wash very badly, but when turned out they are very soon cut up by gullies. Below, or to the south of the prairie region, are the regions underlaid by the upper or Vicksburg division of the White Limestone. But very little of this occurs within the limits of Choctaw.

Materials of economic value.—As might be inferred from the above account of the geolgical relations of Choctaw county, metallic ores are not to be looked for here, except, perhaps, ores of iron, which have sometimes been found of excellent quality, but never, so far as known, in large quantity, within the area of the Buhrstone. The Claiborne greensands occasionally occur oxidized into an iron ore of fairly good quality in some parts of Mississippi, and such ores might also be looked for here.

Marl.—The two most important of the marl beds occurring in Choctaw are the Nanafalia and the Wood's Bluff marls. These, where they can be obtained at small cost, will undoubtedly be of great benefit to the soils. Within the area of the Lime Hills we find occasionally a good deal of gypsum or "isin-glass," as it is sometimes called, mingled with the limy clay of this formation. Gypsum, when ground up, is the material of land plaster, and a good, thick and reliable deposit of it would be a source of great profit. Although crystals of this substance, in some considerable quantity, have been found in very many localities, no deposit has yet been found that promises to be of any commercial value. Gypsum is a mineral which may be very easily recognized, as it crystallizes in clear, glassy forms, andflakes off readily into thin, transparent plates, whence the common name "isin-glass," and it is, moreover, quite soft, and may easily be scratched with the finger nail. Reports of the occurrence of gold and silver in Choctaw, as in many other counties in South Alabama, may all be traced back to the finding of iron pyrites, or "fool's gold," or to Indian legends.

Tripoli.—The light chalky looking parts of the Buhrstone are near of the composition of tripoli and might find appli-

cation where such material is wanted.

Fossil resin.—In the White Limestone at many points a black bituminous matter has been frequently observed. A specimen from the vicinity of Rescueville in this county has been analyzed for me by Dr. Phillips the following results, which show that the substance is a fossil resin to which as yet no specific name has been given:

Analysis of Fossil Resin from near Rescueville.

APPROXIMATE ANALYSIS.

Volatile combustible matter	62.90
Ashed carbon	34.50
Ash	2.30
Moisture	.30
Total	100.00

ULTIMATE ANALYSIS.

Carbon	54.47
Hydrogen	7.72
Oxygen (by difference)	29.71
Nitrogen	.22
Sulphur	5.28
Ash	2.30
Moisture	.30
Total	100.00

CLARKE COUNTY.

In some respects Clarke county is geologically one of the most interesting in the state. The underlying strata are all Tertiary, and range from the Bell's Landing group upwards to the top of the series. Yet because of the Hatchetigbee Anticlinal and perhaps of other disturbances, there are complications in the geological structure which make its study one of exceeding interest.

Bell's Landing.—The extreme northern part of the county is made by the Bell's Landing beds which do not present

any noticeable features of topography or soil, as they form high piny woods on the divides and sandy bottom lands in the low grounds. The features of the upper part of Clarke county are the same as those of the lower part of Marengo and there is no need of repetition.

Wood's Bluff and Hatchetigbee.—As in Choctaw we shall consider these two formations together, since they form a great series of clayey strata holding two or three marl beds, one of which is important, the others insignificant, and several thin beds of lignite which lie close together below the Wood's Bluff marl. The characteristic topography of the Wood's Bluff and Hatchetigbee area is broken, and rugged, with steep clay hills, and narrow valleys between. The soils which are derived from these clays are heavy and often strongly limed by the disintegration and commingling of the marls. The timber shows well the character of the soils which are thus formed, it being chiefly beech with hickory, ash, oaks, short leaf and spruce pines, cucumber trees, etc., all draped with long moss, which is about as good an indication of the character of the soil as any of the timber trees.

At Wood's Bluff on the river we have the marl bed well exposed in all its peculiarities, and the left bank of the river below the landing down to White Bluff is made by the brown Hatchetigbee clays. These last also make up the banks of Witch creek at the foot of White Bluff which in its upper half is formed by the Buhrstone rocks. The lower or southern limit of the Wood's Bluff Hatchetigbee section is very easily followed, since it is formed by the "Mountain," a high rugged ridge of Buhrstone. Tallahatta creek flows for about all its length along the foot of this escarpment, and its bed is mostly in the Hatchetigbee clays, though the Wood's Bluff marl shows in many places where the stream has cut deepest.

Bashi creek, on the other hand, flows for most of its course

along the Wood's Bluff formation, but its tributaries from the north drain the lower part of the Bell's Landing beds in western Clarke. On the Tombigbee side of the divide between the two rivers in Clarke, these two creeks make beautiful exposures of these two formations. In the upper or Wood's Bluff part, the marl bed is a notable feature. This is a bed of greensand filled with shells, and having in many places a thickness of ten or fifteen feet. There is a tendency in this greensand marl to become indurated and to form irregularly shaped but somewhat rounded, bowlder-like masses of tolerably hard rock. This induration is not confined to any definite part of the marl bed, but may be in the upper, middle, or lower part. Underneath the hard ledges thus formed we commonly find the marl in a loose pulverulent condition, and where protected, it is often very dry, so that it is an easy matter to get it out for use on the lands. In this loose marl are found the beautifully preserved shells which have become so well known since 1872. On Cave and Knight's branch, tributaries of Bashi, in T. 11, R. 2 E., there are many caves formed by the washing out of the loose marl from under the indurated ledges. Similar caves are also known about Choctaw Corner, and near the Tombigbee river, and indeed may be considered characteristic of this marl bed wherever it attains any considerable thickness.

It is impossible, without accurate contour maps, to show the exact places of outcrop of these two formations and their limits towards each other, and to the Bell's Landing beds below, because of an undulation in the Tertiary strata constituting what we have called the lower Peach Tree anticlinal. This undulation causes the strata to lie nearly horizontal over a good part of the county, and in such ases, while the Hatchetigbee clays form the summits of the elevations the Bashi or Wood's Bluff marl may be seen down in the banks of the branches. This is the case about Choctaw Corner, where the surface beds and a considerable

thickness of the uppermost strata are of Hatchetigbee sandy clays, while the Bashi marl outcrops in all the streams below the level of the plateau on which the town stands. So also in the low grounds of Tallahatta creek, most of the material is Hatchetigbee, but in the immediate creek bottom the bowlders of Bashi marl are frequently uncovered and exposed. Our lines must therefore be taken as only approximately marking the limits of the two formations. The real limit would be a very intricate line which it would be impossible to draw correctly without examining every foot of the land.

The arch of the Lower Peach Tree anticlinal does not show much on the Tombigbee side of the county but eastward of Choctaw Corner towards Lower Peach Tree it is indicated by the widening north and south, of the area of outcrop of the Bell's Landing and Wood's Bluff strata. This is not very apparent within the Clarke county lines but is well seen in Wilcox.

Going eastward from Choctaw Corner, the pine hills are soon succeeded by "lime hills," that is, steep clay hills well limed by the disintegration of the marl bed which occupies the tops. These are the Wood's Bluff strata, and the country formed by them is very broken. The lime hills when continuously cultivated hold their soil very well, but are badly washed and cut into gullies when left out for a few seasons.

Northward from Choctaw Corner, the Bell's Landing features are soon seen, reddish sandy loam soils in which occur many bowlders of indurated marl. The Hatchetigbee clays give rise in many places to sulphur springs, and a well known locality of this sort is Tallahatta Springs S. 26, T. 11, R. 2 E., in the low lands of the creek of same name.

The Hatchetigbee clays are brought to the surface again further south by the disturbance which produced the Hatchetigbee anticlinal. A back bone or crest of these rocks extend from Choctaw and Washington counties across the

river at Hatchetigbee Bluff and thence southeastward to about the southwestern corner of T. 8, R. 1 E.

Still further south in the vicinity of Jackson, there appears to be another occurrence of the Hatchetigbee formation and the salt and sulphur well at that place comes no doubt from the materials of this formation. We can identify the Hatchetigbee clays a short distance east of Jackson, but at the Middle and Lower Salt Works, (S. 34, T. 6, R. 2 E. and SS. 22, 28, T. 5, R. 2 E. respectively) where the Buhrstone comes to the surface the Hatchetigbee clays do not appear to be actually exposed, though it is probable that the salt wells come out of them at no great distance below the surface.

Buhrstone.—This formation impresses itself upon the topography more decidedly than any other of the Tertiary divisions, for the great bulk of the beds of the Buhrstone consists of hard sandy and aluminous rocks which resist both decomposition and the mechanical action of the weather. They are consequently left as high rugged and rocky hills locally termed mountains. From the character of the greater part of the rocks, it may seen that the soils as a rule, are not fertile, being generally light and sandy. Near the base of the formation, however, there is a considerable admixture of greensands and heavy bedded clays, which form a transition to the Hatchetigbee strata underlying, and the soils derived from these lower beds are much more fertile. The prevailing timber upon these rocky hills, is of course the long leaf pine and and its associates, black jack and post oaks, and where the sands are very heavy, the turkey and high ground willow oaks.

Of *useful materials* in this formation we may mention the indurated clays which are often of a very great degree of purity, and might be used for fire brick. This clay is commonly known as "chalk" and the name "chalk hills" is applied to this region both in Clarke and in Choctaw.

The name "chalk" as thus applied is not entirely inappropriate, since much of this rock, especially the lighter and

more porous varieties, are now known to be made up in great part of the silicious shells of microscopic species of diatoms, and therefore to be of the nature of true *tripoli*, which might be called a "silicious chalk."

These hills or mountains overlook towards the north, the lowlands of Tallahatta creek, and, on the Alabama river side, the lowlands of Bear creek, with steep and precipitous faces, From this crest the slope towards the south is very gradual. The lower third or fourth of this northward-facing escarpment, is made up of the laminated clays of the Hatchetigbee group, while the overlying beds to the summit are indurated clays and sand rocks of the Buhrstone.

At White Bluff on the Tombigbee, a short distance below the mouth of Witch creek, there is a bluff nearly 300 feet high overlooking the river. A perpendicular face of about 100 feet or 120 at the summit is made by the Buhrstone rocks, and below down to the river level is a very steep slope formed by the underlying Hatchetigbee clays. From the summit of the bluff a road goes down on the western side to Martin's Landing where the strata may be fully seen. Upon this, as upon other similar elevated points in the vicinity of the Tombigbee and Alabama rivers, we nearly always see accumulations of rounded water-worn pebbles of quartz, belonging to the Lafayette formation.

On the Alabama River side, the rocks of this formation occur along the river from Hamilton's Landing down to Lisbon.

The head water's of Bassett's and Satilpa Creeks rise on the northern and eastern ledge of this escarpment of Buhrstone and flow into the Tombigbee, consequently the divide between the two rivers is within six or eight miles of the Alabama River throughout the county. This divide in many places, for instance east of Grove Hill, is very narrow, so that gullies on the two sides approach within a few feet of the summit, which is 375 to 400 feet above the river level. This Buhrstone escarpment runs nearly east and west from the Tombigbee to within a few miles of the eastern boun-

dary of the county and then turns abruptly southward to the Alabama River, the rocks of the formation crossing the river near Hamilton's Landing above the mouth of Silver Creek. It is quite possible that this anomalous condition of things, i. e., of the drainage and general topography may be in some way connected with the movement which produced the Lower Peach Tree anticlinal, yet it is not easily explained.

Besides this northern and regular outcrop of the Buhrstone we find another in the western part of the county near Coffeeville and below, where there is a border of these rocks passing around the southeastern end of the Hatchetigbee anticlinal which has been described both in the general section (Part I) and under Choctaw county. These rocks are seen along the Coffeeville and Jackson road a short distance below the former place, and again within six or eight miles of Jackson, the two outcrops being on the opposite side of anticlinal, and we have observed these rocks also at many other points around the end of the anticlinal as shown upon the map. In this part of the county and in the continuation of the outcrop over in Choctaw, the Buhrstone does not form such high and well defined hills as it does along its regular northern outcrop, yet all the distinguishing characters of the formation are here very clearly seen.

Along the Jackson-Coffeeville road we find, seven or eight miles above Jackson a good deal of chalcedony of very good quality among the Buhrstone rocks. Some of this chalcedony is of deep red color like carnelian and would make handsome sets for jewelry if cut and polished. Along the lines of the lower outcrop are some brine wells which were used during the war for salt making. The upper Salt works are upon this line in SS. 16 and 17, T. 7, R. 13.

Other Buhrstone outcrops further south have been noticed near Jackson, and at the Middle or Lower Salt works. In all these places the Buhrstone seems to be directly covered by the White Limestrne, and the Claiborne formation seems to be absent, a state of things which it is very diffi-

cult to account for without further investigation. The salt probably comes from the Hatchetigbee clays underlying the Buhrstone. All the occurrences have been described in some detail in Part I, and a repetition here is not needed.

The Claiborne.—The typical locality of occurrence of this formation is at Claiborne on the Alabama River, but the rocks of the division occur in this county along the river from below Gosport Landing up to Lisbon. The materials being mostly sandy, and not indurated, make very little impression upon the topography, nor do they affect the soils in any great degree, except that where the greensand beds with oyster shells, of the lower part of the formation mingle with the red loam soils of the piny woods, there are formed red limy clay spots known as piny woods prairies.

From Claiborne and Lisbon the outcrop of these beds runs about parallel to that of the Buhrstone, seldom, however, coming to the surface, and they reach the Tombigbee River near the mouth of Turkey Creek, a small stream flowing into the river below White Bluff above mentioned. Another outcrop of these beds may be traced around the end of the Hatchetigbee anticlinal above described, and one well known locality of its occurrence is on Stave Creek in the lower part of T. 8, and upper part of T. 7, R. 1, E. On the lower side of the anticlinal the Claiborne rocks cross the river at Baker's Bluff, and on the upper side, at Coffeeville Landing where a fine section of the lower beds of the group may be seen. Between the regular outcrop south of the Buhrstone Hills and the upper outcrop around the anticlinal, the Claiborne as well as the other strata lie in a shallow basin, the surface of which is occupied by the White Limestone. In many parts of this shallow basin the Claiborne beds lie quite near the surface and are exposed in many of the banks of streams that have cut deep channels.

Thus for instance on one of the small branches of Satilpa Creek, near Mr. Walter Pugh's, in S. 23, T. 9, R. 2. E., al-

most in the center of this White Limestone basin, we find a good exposure of the Claiborne beds with beautifully preserved shells, the thickness of the overlying White Limestone at this place being not much if anything more than 100 feet.

Southward of the Hatchetigbee anticlinal I know of no place where the Claiborne beds come again to the surface except in S. 23, T. 6, R. 2, E., nearly east of Jackson. In the lower part of the county about Jackson, and at the Middle and Lower Salt works where the Buhrstone comes to the surface, with the exception of the locality just named, the Claiborne beds appear to be absent and the White Limestone seems to lie directly upon the Buhrstone. This direct superposition has been observed at two places, but further observation may reveal the presence of the Claiborne here also.

White Limestone.—These rocks form the surface over a larger proportion of Clarke than of any other county in the state. This is caused by the uplift of the Hatchetigbee anticlinal which holds the limestone to the surface over a distance, from north to south, of thirty miles. In the western part of the county, the limestone is not continuous, but is divided by the ridge of underlying rocks thrust up by the forces that formed the anticlinal. These lower rocks, however, are brought to the surface eastward only about six or eight miles from the western county line. Beyond this towards the east the anticlinal shows itself only in the circumstance that it keeps the White Limestone at the surface.

The soils of the White Limestone vary according to the circumstances. The lowermost sixty feet of this formation is made up of a clayey limestone and calcareous clays, which, in weathering, gives rise to heavy calcareous clayey soils called "prairies," and inasmuch as the country where these soils prevail is generally much cut by washes, the name "Lime Hills" is applicable and is commonly in use. Where the upper strata of the formation are the surface

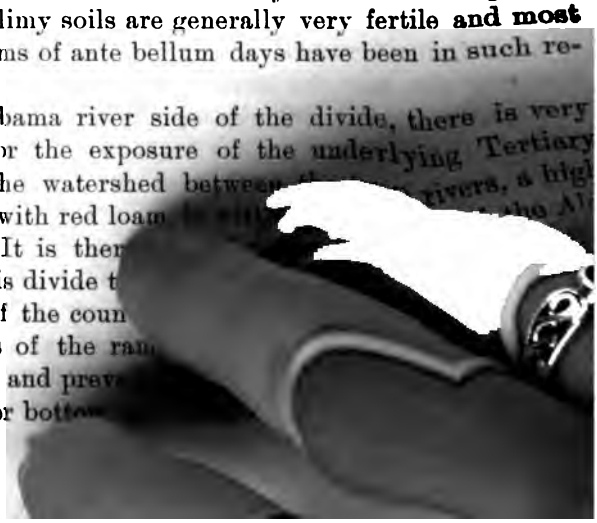
hood of Gosport, etc. We find them again above Grove Hill in a belt between the level plateau upon which that town stands, and the edge of the Chalk Hills region. This belt runs westward into the river bend above Coffeeville, and the limy soils prevail about Col. Thornton's place, and between him and Coffeeville. On the road from Coffeeville to Grove Hill exposures of the White Limestone are seen about five miles from the first named place, and continue for several miles, beyond which a belt of high pine woods is passed to within five miles of Grove Hill, and then White Limestone again nearly up to the town. The prevailing and characteristic timber of these lime lands is short leaf pine, post and red, (Spanish) oaks, sweet gum, sour gum, maple and hickory.

West and southwest of Grove Hill the White Limestone is shown in many places. One of the most interesting of these spots is known as "The Rocks," section 35, T. 9, R. 1 E., the old homestead of the Creagh family. Here we have clearly exhibited the two divisions of the White Limestone formation. The upper of these, called the Vicksburg limestone, here perhaps 100 feet in thickness, is a white limestone filled with the flat coin shaped shells of *Orbitoides*. At intervals of 25 or 30 feet there are hard ledges in this rock, which form a series of terraces around the little limestone hills. These terraces, as well as the intervening slopes, are hardly ever cultivated, but are covered with a dense growth of small cedars. These barren rocks show also a great tendency to break down under the action of the weather into very irregularly shaped fantastic forms (horse-bone rock) which are strewn in great numbers all over the surface of the cedar groves. Below the Vicksburg limestone division is the clayey limestone of the Jackson formation, which gives rise to the prairie soils. Along the upper edges of these lime areas, next to the ledges of Vicksburg rock, we find the ground usually covered with fossil shells which have weathered out of the clayey limestone. Sharks' teeth are abundant as are also the vertebræ of the *Zeuglodon*, the

rocks, very slight connection can usually be traced between them and the soils.

Through most of the region where these upper beds prevail the soils are very sandy and the country is a rolling pine woods, the presence of the limestone below being usually shown only by the limesinks which form a characteristic feature of the landscape. The "Lime Hills" occur in all parts of the county from above Grove Hill down to the latitude of Gainestown, but they do not form any very large proportion of the actual soils, since the White Limestone, as well as the other Tertiary rocks, have been covered with a mantle of red loam, sands, and pebbles, in geologically comparatively recent times, and these surface beds form a very large proportion of the soils. Upon all the high plateaus which separate the greater drainage basins, there is almost universally a covering from fifteen to twenty feet in thickness of red loam underlaid with water worn pebbles of Lafayette age. And since in the denudation which the country has undergone, and which is still in progress, these materials are continually being carried down to lower levels, the complicated nature of the soils will readily be apparent. There are many places, however, where the underlying limestone has, in this denuding process, been laid bare, and where the soils can be traced directly back to it as the parent rock. These limy soils are generally very fertile and most of the fine farms of ante bellum days have been in such regions.

On the Alabama river side of the divide, there is very little space for the exposure of the underlying Tertiary rocks, since the watershed between [illegible] rivers, a high ridge capped with red loam [illegible] bama river. It is ther[illegible] down from this divide t[illegible] eastern part of the coun[illegible] on both sides of the ra[illegible] ships 8 and 9, and prev[illegible] above the river bott[illegible]



numerous limesinks and in places by shallow ponds which have collected in the depressions formed by the limesinks. In all this region the Lafayette is the surface material and the soils and timber are therefore dependent upon this formation. Along the headwaters of Little River there is a small showing of still another kind of land dependent upon the *Grand Gulf* strata. Where these lands occur, and the overlying Lafayette is not very thick, there is a great tendency to form flat badly drained spots especially about the heads of the little branches. This is due to the impervious character of some of the Grand Gulf beds.

The great bulk of the surface of Conecuh is formed by the strata of the *Lafayette*, and the great bulk of its soils are therefore derived from this surface formation. Such soils show the usual variation from fine red loams upon the wide plateaus, to sandy soils of the piny woods upon the narrower ridges. There are however, two or three belts extending across the county in which the lime of the St. Stephens strata comes in to modify the soils and these are the most desirable farming lands. Outcrops of the Tertiary rocks are not very numerous in this county, and except in the case of the hard rocks of the Buhrstone, they are seen only where the overlying later deposits have been moved by erosion, viz. along the water courses.

BUTLER COUNTY.

With the exception of a small area along the head waters of Cedar creek and Pigeon creek in the extreme northern part of the county the underlying rocks of Butler are Tertiary, and range from the Clayton or Montery division up to the Buhrstone.

Cretaceous.

These rocks are only the uppermost of the *Ripley* series consisting of bluish calcareous sands with indurated ledges at intervals through them. They underlie immediately and conformably the Turritella rock of the lowermost Tertiary.

They are seen everywhere along the course of Cedar creek in this county and also to the north of the Little Texas Hills. In all these localities the Nautilus and Turritella rocks occur at slightly higher elevations. Where the Ripley sands appear in the banks of the creek the other rocks named are seen in the creek bottoms or low grounds, and where the Tertiary rocks cap hills of considerable heights the Cretaceous sands are found along the hill slopes and in the valleys between. They do not take any very important part in the formation of the soils in Butler county.

Tertiary.

Clayton or Midway.—The rocks of this division, the lowermost of the Tertiary, appear in considerable force in the Little Texas region above spoken of, lying on both sides of Cedar creek and especially to the north of it. South of the creek these rocks are at low levels, not much elevated above the creek bottom, but north of the creek they appear capping some of the highest and most rugged hills of this part of the state. Typical exposures of these may be seen on the road between Monterey and Bragg's store in Lowndes and on the road leading from Monterey over Steen's Bridge. The Nautilus rock in the hills north of the creek has in places a thickness of forty or fifty feet, and caps the rugged hills that give character to this section. The underlying Turritella rock is usually only a few feet thick. At places a very good quality of fibrous limonite occurs in the Little Texas hills overlying the nautilus rock but it seems nowhere to be present in any great quantity, unless perhaps near Searcy station on the railroad.

Lignitic.—In the vicinity of Monterey and thence eastward and southeastward by Manningham, Greenville, etc., the strata described in the Oak Hill section in Wilcox county make the country. These beds occur along the usually steep hillsides and slopes looking northward and northwestward over the low grounds of Wolf and Pine Barren creeks and between Wolf and Cedar creeks further

east. Along these slopes all the strata of the Oak Hill section are presented, from the Dale Branch or Mathews' Landing marl bed (Nahcola, which may be seen on Brewsworks creek west of Monterey and in the depressions about that town, down to the Black Bluff prairie clays which make the fertile bottom lands of Wolf and Pine Barren creeks. Near the base of the hills which border these black prairie bottoms, the yellowish sandstone ledge which we have usually called the Wall rock, may everywhere be seen. Under this ledge are caverns of considerable size, as for instance on the Monterey and Snow Hill road. All these hill-slopes are very rough and broken, and the growth of varieties of magnolia, and their associates, indicates a fertile soil. But since most of these strata are reddish and yellowish calcareous sands (in this region with a very large percentage of mica), they are easily washed into gullies and are not much cultivated on that account. Where, however, they lie in favorable position they are generally cultivated, especially where they border on the black prairie clays. The whole region about Monterey recalls that around Allenton in Wilcox and the geological position is identical. The greensand bed associated with the Dale Branch marl about Monterey is in places oxidized thoroughly into limonite and casts of the shells in the same material are common, e. g., at the McKee old place west of Monterey. The limonite is too much contaminated with sand to be of any commercial value. On the Charlie Scott place there is a good deal of limonite or brown iron ore of very fair quality, which may some day prove of value if found in sufficient quantity. Strong chalybeate springs characterize this horizon about Monterey. The Nahcola series of greensand marls appear at intervals from Monterey to Greenville, and where the strata of this series make the surface they often give rise to the formation of tolerably level plateaus with deep red soil, which is difficult to distinguish from that of the Lafayette red loam, except where the greensand fossils appear.

A well known topographic feature of this county is "the Ridge," which is the high land left by erosion between the

waters of Wolf and Cedar creeks which flow somewhat parallel with each other for several miles. This ridge is made up of the strata of the Oak Hill section, and the Naheola marl bed crops out at many places along it. This, which is a greensand marl, is usually fully oxidized in the ridge and its fossils are seen only in the form of casts or moulds. The great bulk of the strata composing the ridge are yellowish micaceous sands. This part of the county was at one time the center of the civilization and culture in Butler county. Upon the ridge were the houses of the planters who cultivated the rich prairie soils of Cedar creek lying at the foot of it towards the north. At the present time very few white families are to be found here, and the whole section, from long neglect, is badly cut up by gullies, and the once fine houses of early days have fallen into decay and the Ridge now presents a scene of delapidation painful to behold.

The line between the Naheola and the next overlying set of Tertiary strata is pretty well marked in the transition from red loam soils with much fine oak and hickory timber, to the piny woods and black jack country made by the strata of the Nanafalia series.

A belt of this kind of land crosses the county nearly east and west from the southeastern corner of Wilcox. Butler Springs, the old watering place, is in the midst of it, and the belt will average perhaps five or six miles width across the county, and is characterized by reddish clay soil generally with long leaf pine, post and black jack oaks. In many parts, especially along the northern border of the belt, somewhat indurated rocks, our *pseudo-buhrstone*, are common, while in other parts the strata are loose sands, with the characteristic shell of this section, *gryphæa thirsæ*.

To the south of this strip of land lies that made by the sands and clays of the Bell's Landing or Tuscahoma series, and while the materials appear to be practically the same as those of the preceding section, the soils and the general character of the country made by them are quite different.

bones as well as the shells occurring usually in the upper strata of the soil-making formation. These bones are, as a rule, badly preserved, and it is not an easy matter to find a perfect one.

In the Jackson limestone we find also, at many places, a black bituminous substance resembling coal, but much lighter and freer from ash and apparently identical with that which occurs in the Cretaceous formation of Marengo. This also occurs in isolated pockets and not in continuous beds. I have seen this same material also near Suggsville, so that it appears not to be very uncommon, although it is not anywhere found in large quantity. The analysis of a similar substance from this horizon, from near Rescueville in Choctaw county, shows this to be a fossil resin.

In most of the prairie fields there are numbers of rounded and irregularly shaped nodules of the phosphate of lime, which, if abundant enough, might well be utilized.

Many other exposures of the White Limestone, in both its phases, occur to the west of the road leading from Grove Hill to Jackson, while along the road we see scarcely anything but high piny woods, with limesinks here and there, showing the presence of the White Limestone at no great distance below the surface, but covered with sands and loam of the later formation.

Below Bassett's Creek the country in the fork is generally a high piny woods region, with magnificent timber. Here and there, however, on both sides of the divide, erosion has carried away the covering sands and exposed the limestone. In a hill a few miles east of Jackson we see an outcrop of Buhrstone, and, immediately adjacent to it, the White Limestone. This last named rock is also seen in some of the deep gullies about this ridge.

Then, towards the south, at Salt Mountain (S. 34, T. 6, R. 2, E.), we have an exposure not only of the ordinary Vicksburg or Orbitoidal rock, but, above it, in the "Mountain," about 150 feet of a limestone seen nowhere else in the state. This part of the limestone is filled with silicified corals. At

the base of the "Mountain" are numerous salt wells or springs, arising, in all probability, from the still deeper lying Hatchetigbee beds. As has been already mentioned, we have about the Central Salt Works many localities where the White Limestone lies directly upon the Buhrstone, and the whole Claiborne formation seems to be absent.

Another locality, still further south, where these rocks come to the surface, is in S. 21, T. 5, R. 2, E., at the Lower Salt Works, and for some distance both north and south of this.

Here, as above, the White Limestone seems to lie directly upon the Buhrstone, and there is no sign of the Claiborne beds. All these localities south of Jackson have been described in some detail, in the general section, Part I, under the heading of "Buhrstone Displacements," and it is needless to repeat what has been said there. At Oven Bluff, on the river, in S. 8, T. 4, R. 2, E., we have the most southerly outcrop of Tertiary rocks on the Tombigbee River. Here it is the White Limestone (Orbitoidal), and it is at the water level. In T. 5, R. 2, E., there are numerous other exposures of the White Limestone besides those already enumerated, where the streams have washed away the covering sands.

In the Fork between the two rivers this rock is deeply covered with drifted materials, but, as we approach the Alabama River, we find these surface materials in places removed and the underlying rocks exposed.

The furthest south of any exposure of Tertiary rocks on the Alabama River occurs at Choctaw Bluff, and the rock seen there is the lowermost or Jackson division of the White Limestone, and not the Vicksburg, as might have been anticipated.

Above this, at the Gainestown Landing, the Jackson rocks of the White Limestone are again seen. Here there is a very good limestone which has been quarried for building purposes. In this section also occurs *gypsum*, but, so far as I know, not in quantity sufficient to make it of any economical importance.

In the bend of the river, above Gainestown, there are many exposures of the limestone and occurrences of "Lime Hills."

On the waters of Cedar Creek we have a state of things somewhat similar to what has been described at the "Rocks." The Vicksburg or upper division of the White Limestone prevails here, and, as it consists of soft strata alternating with indurated ledges, the country where it occurs presents a series of natural terraces overgrown with dense thickets of cedar.

At Suggsville and at several points along Bassett's Creek, between Suggsville and Jackson, the White Limestone is exposed, as is also the case between Suggsville and Claiborne.

North of Suggsville the White Limestone is seen in numerous places towards Grove Hill. Some three miles north of the first named town there occurs, as at the "Rocks" a black, bituminous substance, the fossil resin above spoken of, in pockets in the limestone. In most of these exposures on the Alabama River side of the divide, bones of *Zeuglodon* are abundant.

The White Limestone is seen along the whole length of Bassett's Creek, and on most of its tributaries. It has been noticed, as regards their soil-forming characters, that the two divisions of the White Limestone differ very widely. The lower division, being composed of clays and clayey limestones, in disintegrating produce black, heavy, limy, clay soils. On the other hand the upper or Vicksburg division, consisting of a much purer form of limestone, does not readily give soils like those of the Jackson, yet, where the washings from this limestone mingle with the red clay loam of the surface drift, there is formed a kind of red, limy, clay soil that is very fertile and much prized. Where the soil is derived entirely from the limestone it is generally thin and covered with a dense growth of small cedars. In this particular it closely resembles the limestones of some of the Si-

lurian formations of the northern part of the state, particularly the lower part of the Trenton.

Superficial beds. Mention has been made in several places, of beds of sand, pebbles and loam, overlying the Tertiary rocks of this and other counties in this part of the State. These materials form a mantle of perhaps twenty feet thickness over the Tertiary rocks, where they have suffered least from erosion. The main water sheds between the larger streams are high level plateaus some three hundred feet or more above the water level in the rivers. Upon these plateaus we always find these post-Tertiary or Lafayette beds, sand and red loam at top, with pebbles below. In later times erosion has carried these materials down and strewn them upon the lands below. These beds appear, from the observations which we have made in many counties, to have some connection with the ancient channels of the two rivers, for they are not commonly seen at a greater average distance than fifteen miles on each side of these streams; the pebbles seem to have been laid down in a belt about thirty miles wide in which the present rivers have cut their winding channels many feet deeper. These surface materials play a most important part in the formation of the soils of this part of the state as has been set forth in my Agricultural Report for 1881-2.

The following details will show the irregularities in materials and stratification which characterize the Lafayette formation everywhere.

The town of Jackson is situated upon the third terrace about 150 feet above the river level. The surface material over the greater part of this terrace is the red loam so often spoken of. It is perhaps some 8 to 10 feet in thickness, and below it an equally variable stratum of pebbles. In some places these two beds, aggregating some 15 to 20 feet, constitute the whole of the recent beds overlying the Tertiary of the country. But in gullies and washes there are at many points exposures that show other variable beds. The section and remarks below, will exhibit these variations sufficiently well.

Section of Lafayette near Jackson, Ala.

1. Red sandy loam of variable thickness.....8–10 feet.
2. Gravel beds and cross-bedded sands, very variable.....8–10 feet.
3. Red sands with very few pebbles.....3 feet.
4. Pebble beds similar to No. 2.....3 feet.
5. Red and variegated sands, and white clay.....8 feet.

In this gully Numbers 2, 3 & 4, in places run together forming a solid bed of pebbles 15 feet thick. The sands of No. 5 vary, being at times yellow, banded with red, again pure white. Clay pellets are imbedded in the sands; the clay is white and plastic.

In another gully close by the same beds are to be seen, but the details differ, and in no two parts of the same gully will you see the same section. Here the lower beds included under No. 5 of the preceding section, thicken up very greatly and form a great mass of light yellow and white sands, traversed by bands 4 or 5 inches thick, of pebbles of pure white color. These pebbles are of white quartz, and varieties of white chert, much of it being fossiliferous (Subcarboniferous); many of the chert pebbles are of oolitic structure, and many of them contain the rhombohedral cavities. Some of them are 4 or 5 inches long, and one or two inches in thickness. Below the white sand and pebbles in this gully, is a bed of plastic clay of white, yellow and chocolate brown colors. The yellow might possibly make a fairly good ochre, and in another place near Capt. Wainwright's house, there is an ochre bed in a similar gully. In going down the gully, the clays soon give out, and the red loam and pebbles which constitute the upper beds of the section given, are the only beds seen and they appear to cover the slopes of the hill for many feet below as a kind of mantle of approximately uniform thickness. The same pebbles, beds and red loam may be seen almost anywhere in going down the hills leading from this terrace.

MONROE COUNTY.

Across Monroe just above the middle line of the county passes a range of high and rugged hills made by the Buhrstone, and north of these the country is somewhat broken and varied. Southward of these hills the land slopes away southward in gently undulating plains, the home of the long leaf pine.

Only the upper measures of the Tertiary from the Nanafalia up form the substratum of Monroe county, and the formation named occurs only in the northeastern part of the county in the lower edge of the Grampian Hills.

Bell's Landing. The upper edge of Monroe is made by the rocks of this group, which being mostly sandy and glauconitic (containing greensand,) give rise to very characteristic, easily recognized topography and soils, which are nevertheless difficult to describe. The country is undulating and the soil principally a sandy red loam. The timber short leaf pine, and the various upland oaks. This type of country may be seen at Newtown Academy, and eastward towards Turnbull and thence out to Bursonville and beyond into Butler county. West of Newtown Academy the road to Bell's Landing passes through the same region.

At Bell's Landing occurs the marl bed which affords such large and beautifully preserved fossil shells.

Wood's Bluff and Hatchetigbee.—These clayey beds contain a greensand shell marl, occupying a strip of lowlands usually, lying immediately to the north of the escarpment of Buhrstone Hills. The same materials are to be seen below Bell's Landing on the Claiborne road, form the first named place down to Johnson's Wood Yard. The Wood's Bluff strata lie at the surface on hill tops at Bell's Landing and are at the water level at the Wood Yard above mentioned. On the western side of the river the outcrop runs northwest below the edge of the mountain. East of the river the outcrop of these clayey beds runs northeast around a point of the Buhrstone mountain in the eastern part of T. 9, R. 7, from

which point it sweeps southward, to turn again up around a point of the mountain in T. 9, R. 10, E., beyond which it again turns southward in Conecuh and Butler counties. This sweep southward between the two points named is due to the erosion of the lower branch of Flat Creek, which has its channel in the Wood's Bluff and Hatchetigbee clays from its head waters to the junction with the north branch.

Near the head waters of this creek in T. 9, R. 10, the summits of the hills are of Buhrstone, while the Hatchetigbee and Wood's Bluff beds occupy the hill-sides and lowlands, thus making the correct mapping almost impossible; the lines on the map are, therefore, only approximate. Near Midway or Cokerville, (P. O. Activity), in the center of S. 27, T. 9, R. 10, E., both branches of Flat Creek take their rise out of the Hatchetigbee and Wood's Bluff clays at the foot of these Buhrstone capped hills. The northern branch flows thence northwest and west, draining the Bell's Landing area while some of its tributaries flow down from the Nanafalia area or Grampians. Near its confluence with the southern branch it comes again into Wood's Bluff terranes.

The southern branch rising in the same region flows nearly westward parallel with and at the foot of the escarpment of Buhrstone hills to its confluence with the north prong, below which the combined streams pass at once southward through the Buhrstone. This arrangement of the two prongs explains the origin of the celebrated lime lands of Flat Creek. Those of the southern branch are derived from the Hatchetigbee and Wood's Bluff beds which form its channel along its whole course. The northern branch has the Wood's Bluff marl at its head waters while further along its course it receives the washings from the Nanafalia marl, brought down by some of its tributaries. Between the two streams lies the outcrop of the Bell's Landing beds, which form a red sandy loam of fairly good quality.

Buhrstone.—The northern limit of the hills formed by the rocks of this group, is an irregularly waving line across the county. Crossing the river about Hamilton's Landing, the

outcrop runs northeast to a point in the eastern part of T. 9. R. 7 E., the water shed between Flat Creek and the river; beyond this the line of outcrop is carried in a loop southward by the erosion of Flat Creek, but reaches far to the north again on the divide between the waters of Flat Creek and the head waters of the streams flowing south into Conecuh River.

As in other parts of the State, the Buhrstone rocks form high rocky hills with sandy soils timbered with long leaf pine, with areas of more fertile land where the greensand beds come to the surface. In many places we find in the Buhrstone hills good specimens of brown iron ore of fibrous texture, and in appearance equal to best of the brown ores of North Alabame.

This ore does not, however, seem to be present in any quantity. Of useful materials of the Buhrstone I may repeat, that some of the indurated clays will undoubtedly serve for fire proof clays, while some of the softer sandstones are everywhere worked into blocks for building purposes, in making chimneys, pillars, etc.

Claiborne.—South of the lower limit of the Buhrstone is a belt of hilly country where the Claiborne sands are exposed.

The hills of this region are different from those of the Buhrstone, being capped towards the lower edge of the belt with the White Limestone, and then presenting all the characters of the Lime Hills of Clarke and Choctaw. As in these counties the Claiborne sands themselves make very little impression upon the topography but appear in places in the soils, as piny woods prairie spots, caused by the mixture of the calcareous matter of the Claiborne sands with the red clay loam subsoil of the piny woods. The Claiborne formation is celebrated throughout the world for the great number and beauty of preservation of the shells which are found in some of its uppermost beds. The best known locality is at the Bluff of Claiborne Landing, described in detail elsewhere, Part I.

east. Along these slopes all the strata of the Oak Hill section are presented, from the Dale Branch or Matthews' Landing marl bed (Naheola) which may be seen on Breastworks creek west of Monterey and in the depressions about that town, down to the Black Bluff prairie clays which make the fertile bottom lands of Wolf and Pine Barren creeks. Near the base of the hills which border these black prairie bottoms, the yellowish sandstone ledge which we have usually called the Wall rock, may everywhere be seen. Under this ledge are caverns of considerable size, as for instance on the Monterey and Snow Hill road. All these hill-slopes are very rough and broken, and the growth of varieties of magnolia, and their associates, indicates a fertile soil. But since most of these strata are reddish and yellowish calcareous sands (in this region with a very large percentage of mica), they are easily washed into gullies and are not much cultivated on that account. Where, however, they lie in favorable position they are generally cultivated, especially where they border on the black prairie clays. The whole region about Monterey recalls that around Allenton in Wilcox and the geological position is identical. The greensand bed associated with the Dale Branch marl about Monterey is in places oxidized thoroughly into limonite and casts of the shells in the same material are common, e. g., at the McKee old place west of Monterey. The limonite is too much contaminated with sand to be of any commercial value. On the Charlie Scott place there is a good deal of limonite or brown iron ore of very fair quality, which may some day prove of value if found in sufficient quantity. Strong chalybeate springs characterize this horizon about Monterey. The Naheola series of greensand marls appear at intervals from Monterey to Greenville, and where the strata of this series make the surface they often give rise to the formation of tolerably level plateaus with deep red soil, which is difficult to distinguish from that of the Lafayette red loam, except where the greensand fossils appear.

A well known topographic feature of this county is "the Ridge," which is the high land left by erosion between the

Grand Gulf.—Between Shomo's Creek and Little River in the southwestern part of Monroe there are very few exposures of Tertiary rocks, but the clays and sands about the head waters of Shomo's Creek and westward can be no other than Grand Gulf. The area here included is small, and exhibits nothing peculiar, being a continution of the open piny woods that characterize all the lower part of Monroe.

CONECUH COUNTY.

The greater part of Conecuh rests upon the strata of the upper divisions of the Eocene, viz., the Claiborne and the St. Stephens or White Limestone. There is a small area in the extreme northern point of the county in which the strata of the Wood's Bluff, Hatchetigbee, and Bell's Landing series are encountered, but the part they take in the determiuation of the topography and the production of the soils is comparatively insignificant. To the east of Activity P. O. to the edge of Butler the country underlaid by the *Bell's Landing beds*, has the same general character as that about Newtown Academy in Monroe: reddish sandy soil, with a timber consisting of short leaf pine, with black jack and Spanish oaks.

Activity P. O. which is upon the border of this county with Monroe but in the latter, stands upon a hill of Buhrstone strata, which are hard silicious sandstones and silicious claystones. Coming southward and southeastward into Conecuh county the road passes over the ontcrops of these hard rocks in descending towards Sepulgah Cr., the general trend of the rocks heing nearly north and south instead of east and west as is usually the case. Near the house of Mr. Wesley Dunn, a mile north of Sepulgah P. O., the *Wood's Bluff marl* may be seen in the banks of a small branch. At this place the marl is interbedded with the lignite, in a very peculiar way, as if both marl bed and lignite had been broken up and deposited *pell mell* together. But the beds do not show much sign of having been transported by water, for

as far as Sparta, being on an average about six miles wide.

The soils of this derivation are stiff clayey loams generally highly charged with lime, and resting upon a stiff clay subsoil. The red lime lands of this kind are well seen along the drainage area of Murder creek as it traverses this belt, and some of the best lands in the county are located here. Along the lowlands of Bottle and Beaver creeks the same red lime soils prevail. The divides between these creeks with the limy soils are usually capped by a mantle of pebbles, sands and loams of the Lafayette formation and the characteristic timber is the long leaf pine. When these divides are wide, they assume the characters of broad level plateaus with fine red loam soil. Bellville is upon such a plateau between the waters of Murder and Burnt Corn creeks. Plateaus of this kind have had frequent mention in this report; they have an average elevation of some 400 to 500 feet above tide, and while the soils are not so fertile as those where the lime of the St. Stephens exerts its influence, yet they are very generally cleared up and in cultivation, and have been occupied from the first settlement of the country.

Along the slopes leading down to the streams above mentioned, the limestone appears sometimes in a solid bed but often in the form of rocky knolls which are the remnants of the rock left by the weathering away of the rest. These knolls are not much in cultivation for the reason that they are generally too rough and rocky from fragments of the limestone. The soil however, which surrounds them is a very rich black prairie-like soil, which is exceedingly valuable where it lies in a position where it may be cultivated.

The upper part of the St. Stephens formation, which occupies all the lower part of the county below Sparta, and a much wider area in the southwestern part of the county, has usually very little influence upon the soil, although it is a moderately pure limestone in places. The territory underlaid by it is almost everywhere an open rolling piny woods country, in which the underlying limestone is betrayed by

numerous limesinks and in places by shallow ponds which have collected in the depressions formed by the limesinks. In all this region the Lafayette is the surface material and the soils and timber are therefore dependent upon this formation. Along the headwaters of Little River there is a small showing of still another kind of land dependent upon the *Grand Gulf* strata. Where these lands occur, and the overlying Lafayette is not very thick, there is a great tendency to form flat badly drained spots especially about the heads of the little branches. This is due to the impervious character of some of the Grand Gulf beds.

The great bulk of the surface of Conecuh is formed by the strata of the *Lafayette*, and the great bulk of its soils are therefore derived from this surface formation. Such soils show the usual variation from fine red loams upon the wide plateaus, to sandy soils of the piny woods upon the narrower ridges. There are however, two or three belts extending across the county in which the lime of the St. Stephens strata comes in to modify the soils and these are the most desirable farming lands. Outcrops of the Tertiary rocks are not very numerous in this county, and except in the case of the hard rocks of the Buhrstone, they are seen only where the overlying later deposits have been moved by erosion, viz., along the water courses.

BUTLER COUNTY.

With the exception of a small area along the head waters of Cedar creek and Pigeon creek in the extreme northern part of the county the underlying rocks of Butler are Tertiary, and range from the Clayton or Montery division up to the Buhrstone.

Cretaceous.

These rocks are only the uppermost of the *Ripley* series consisting of bluish calcareous sands with indurated ledges at intervals through them. They underlie immediately and conformably the Turritella rock of the lowermost Tertiary.

They are seen everywhere along the course of Cedar creek in this county and also to the north of the Little Texas Hills. In all these localities the Nautilus and Turritella rocks occur at slightly higher elevations. Where the Ripley sands appear in the banks of the creek the other rocks named are seen in the creek bottoms or low grounds, and where the Tertiary rocks cap hills of considerable heights the Cretaceous sands are found along the hill slopes and in the valleys between. They do not take any very important part in the formation of the soils in Butler county.

Tertiary.

Clayton or Midway.—The rocks of this division, the lowermost of the Tertiary, appear in considerable force in the Little Texas region above spoken of, lying on both sides of Cedar creek and especially to the north of it. South of the creek these rocks are at low levels, not much elevated above the creek bottom, but north of the creek they appear capping some of the highest and most rugged hills of this part of the state. Typical exposures of these may be seen on the road between Monterey and Bragg's store in Lowndes and on the road leading from Monterey over Steen's Bridge. The Nautilus rock in the hills north of the creek has in places a thickness of forty or fifty feet, and caps the rugged hills that give character to this section. The underlying Turritella rock is usually only a few feet thick. At places a very good quality of fibrous limonite occurs in the Little Texas hills overlying the nautilus rock but it seems nowhere to be present in any great quantity, unless perhaps near Searcy station on the railroad.

Lignitic.—In the vicinity of Monterey and thence eastward and southeastward by Manningham, Greenville, etc., the strata described in the Oak Hill section in Wilcox county make the country. These beds occur along the usually steep hillsides and slopes looking northward and northwestward over the low grounds of Wolf and Pine Barren creeks and between Wolf and Cedar creeks further

east. Along these slopes all the strata of the Oak Hill section are presented, from the Dale Branch or Matthews' Landing marl bed (Naheola) which may be seen on Breastworks creek west of Monterey and in the depressions about that town, down to the Black Bluff prairie clays which make the fertile bottom lands of Wolf and Pine Barren creeks. Near the base of the hills which border these black prairie bottoms, the yellowish sandstone ledge which we have usually called the Wall rock, may everywhere be seen. Under this ledge are caverns of considerable size, as for instance on the Monterey and Snow Hill road. All these hill-slopes are very rough and broken, and the growth of varieties of magnolia, and their associates, indicates a fertile soil. But since most of these strata are reddish and yellowish calcareous sands (in this region with a very large percentage of mica), they are easily washed into gullies and are not much cultivated on that account. Where, however, they lie in favorable position they are generally cultivated, especially where they border on the black prairie clays. The whole region about Monterey recalls that around Allenton in Wilcox and the geological position is identical. The greensand bed associated with the Dale Branch marl about Monterey is in places oxidized thoroughly into limonite and casts of the shells in the same material are common, e. g., at the McKee old place west of Monterey. The limonite is too much contaminated with sand to be of any commercial value. On the Charlie Scott place there is a good deal of limonite or brown iron ore of very fair quality, which may some day prove of value if found in sufficient quantity. Strong chalybeate springs characterize this horizon about Monterey. The Naheola series of greensand marls appear at intervals from Monterey to Greenville, and where the strata of this series make the surface they often give rise to the formation of tolerably level plateaus with deep red soil, which is difficult to distinguish from that of the Lafayette red loam, except where the greensand fossils appear.

A well known topographic feature of this county is "the Ridge," which is the high land left by erosion between the

waters of Wolf and Cedar creeks which flow somewhat parallel with each other for several miles. This ridge is made up of the strata of the Oak Hill section, and the Naheola marl bed crops out at many places along it. This, which is a greensand marl, is usually fully oxidized in the ridge and its fossils are seen only in the form of casts or moulds. The great bulk of the strata composing the ridge are yellowish micaceous sands. This part of the county was at one time the center of the civilization and culture in Butler county. Upon the ridge were the houses of the planters who cultivated the rich prairie soils of Cedar creek lying at the foot of it towards the north. At the present time very few white families are to be found here, and the whole section, from long neglect, is badly cut up by gullies, and the once fine houses of early days have fallen into decay and the Ridge now presents a scene of delapidation painful to behold.

The line between the Naheola and the next overlying set of Tertiary strata is pretty well marked in the transition from red loam soils with much fine oak and hickory timber, to the piny woods and black jack country made by the strata of the Nanafalia series.

A belt of this kind of land crosses the county nearly east and west from the southeastern corner of Wilcox. Butler Springs, the old watering place, is in the midst of it, and the belt will average perhaps five or six miles width across the county, and is characterized by reddish clay soil generally with long leaf pine, post and black jack oaks. In many parts, especially along the northern border of the belt, somewhat indurated rocks, our *pseudo-buhrstone*, are common, while in other parts the strata are loose sands, with the characteristic shell of this section, *gryphœa thirsœ*.

To the south of this strip of land lies that made by the sands and clays of the Bell's Landing or Tuscahoma series, and while the materials appear to be practically the same as those of the preceding section, the soils and the general character of the country made by them are quite different.

The country is gently rolling and the timber is chiefly short leaf pine with black jack and post oaks. This section is the counterpart of that about Lower Peach Tree and about Newtown Academy in Wilcox, and is a continuation of what we have been in the habit of calling the Pineville-Peach Tree belt, which is sufficiently marked to be easily recognized in the field though perhaps impossible to characterize definitely in words.

The strata of the Hatchetigbee and Woods Bluff horizons do not make any definite show in Butler, except in the character of the soils and timber. We have not seen a section of these strata that could be very certainly identified by its fossils. The nearest outcrop of them is in the edge of Wilcox county adjoining, and near Sepulgah P. O. What is called Oakey Streak in Butler is evidently, according to Mr. Langdon's observations, based upon these strata. This is a belt about twelve miles long and seven or eight wide in the lower southeastern part of the county, characterized by the occurrence of light colored laminated clays, interstratified with cross-bedded sands that show in all the branches and washes, but without thus far revealing any definable fossils. The timber is short leaf pine with red, Spanish, post and white oaks, and in the best localities the pines are few in number and oaks and hickories make the timber. It seems quite possible that part of the Oakey Streak region is based upon the Tuscahoma strata also.

The extreme lower edge of Butler is made by the strata of the Buhrstone, which crop out in high hills in Sec. 27, T. 7, R. 15 E., and extend thence into Covington. The same rocks appear also further westward along Pigeon creek and Sepulgah.

Soils.—From what has been said already, the general distribution of the soil varieties will be easily understood. In the northern part of the county are the lime hills of the upper Cretaceous, merging into the rocky, broken country of "Little Texas," to which both the Cretaceous calcareous sands and the lowermost Tertiary sandy limestones con-

tribute. The lowlands of Cedar Creek and the headwaters of Pigeon Creek below Fort Deposit are types.

Then the black clays and other calcareous beds of the next overlying strata make the *prairies* of Pine Barren and Wolf Creeks, and the fine red lands plateau of Monterey, Manningham and Greenville. Then follows the piny woods belt of the Nanafalia, and then the short leaf pine and oak belt of the Tuscahoma and Hatchetigbee, and, lastly, the rugged hills of the Buhrstone, which, however, away from the streams, makes rather an elevated, level, piny woods tract. As the streams are approached the hard rocks of the Buhrstone are uncovered and make rugged scenery.

Useful materials.—In the Little Texas region and the Monterey plateau, adjoining, are some occurrences of very good limonite, which, if in sufficient quantity, might be of value. The best show of this ore is near Searcy Station, on the L. & N. Railroad, where beds several feet in thickness over a considerable area. In the Monterey region, also, strong chalybeate springs are common, and sulphur springs characterize the Nanafalia belt just to the south of it.

CRENSHAW COUNTY.

Cretaceous.

That part of Crenshaw county embraced in townships 10 and 11, *i. e.* the northern part, is underlaid by the strata of the *Ripley* division of the Cretaceous, micaceous and calcareous sands, with occasioal ledges of impure fossiliferous limestone. The rest of the county has for its underlying beds the strata of the Tertiary, from the Clayton up to the summit of the Lignitic division. In entering this county from Montgomery county, the line between the limy lands of the Rotten Limestone and the sandy soils of the Ripley, occurs about the border between the two counties, where the rather level prairie lands of Montgomery give way to the hills of Crenshaw. As far south as Highland Home these hilly lands are timbered very generally with short leaf pine, with black jack, post and red oaks, hickory, and Spanish

oaks. A few miles below Highland Home the longleaf pine becomes the prevailing tree, with its accompanying oaks, and continues down to the border of Covington. Below Highland Home the country is rolling rather than hilly.

A mile or two south of Strata a ledge of gray, sandy limestone, with many casts of Cretaceous fossils, causes a line of hills extending nearly east and west. Near the summit of this hill the soil is of a deep red color, and the ground is, in places, covered with pebbles of brown iron ore, often as much as an inch in diameter. There is a considerable width of these red lands, which resemble the so-called "buncombe" lands of Mississippi, which are based upon the very same formation. In Crenshaw this is generally known as gravel land, and, though fertile, is not so much prized as farming land as are the limy hills to the north of them, as the gravel makes the cultivation somewhat troublesome. Argus and Highland Home are situated upon a high plateau capped with the pebbles and red loam of the Lafayette formation, which covers the underlying Cretaceous, except at intervals where it has been removed by erosion. This plateau is similar to those seen, at intervals, all over the coastal plain, and a mile or two south of Highland Home it passes very gradually into rolling long leaf pine lands, which make the country for many miles in that direction.

Tertiary.

Three of the divisions of the Lignitic are most largely concerned in the structure of the lower part of Crenshaw. These are: (1.) The Clayton or Rutledge limestone; (2.) The Nanafalia; (3.) The Tuscahoma or Bell's Landing. The other divisions are either very thin, and consequently occupying an insignificant part of the surface, or they are absent entirely.

(1.) *The Clayton.*—About Rutledge there are many outcrops of a soft, white limestone very closely resembling the rock of the St. Stephens Bluff. This limestone may be seen in the banks of the Patsaliga, and is quarried at several points near the Court House for burning into lime for build-

ing purposes. This rock has been referred by Mr. Langdon to the lowermost division of the Lignitic, viz., the Clayton, from its position with reference to the other formations, and not from any otherwise certain evidence, for no characteristic fossils have yet been discovered in it. The peculiar phase of this rock seen about Rutledge seems to be rather local, and has not been observed by any of us at any great distance from Rutledge. In the adjoining counties it presents quite a different appearance. Throughout the region of its occurrence the soils and the general surface characteristics are determined by the overlying Lafayette sands, and not by the limestone, except in so far as the limesinks make a feature of the topography. All this territory is therefore rolling pine land, with upland oaks, and exhibits the soil varieties of the Lafayette. Mr. Langdon's article contains several references to occurrences of this formation in Crenshaw, and to this the reader is referred.

The strata of the Naheola division have not been identified in Crenshaw, though they probably make a narrow strip between the Clayton and the Nanafalia.

(2.) *The Nanafalia* in this county has been recognized at many points by its characteristic shell, the *Gryphœa thirsœ*, and in fragments of the indurated marl rock to which we have given the name "*pseudo buhrstone*," from its resemblance in physical characters to the true buhrstone which occurs much further south. The territory of the Nanafalia will average about six miles in width below Luverne, and is generally rolling piny woods, as might be inferred from the character of the Nanafalia strata, which are mostly sands. Mr. Langdon has identified the formation by its shells at many places.

(3.) To the southward of the Nanafalia the country is made by the strata of the *Bell's Landing* or *Tuscahoma* division, which, though generally sandy, contains more lime than the preceding, and over the region of its outcrop we find a good deal of gently undulating short leaf pine lands, with good oak and hickory growth intermixed. Here, as

elsewhere in the lower part of the state, the Lafayette sands are responsible for a very considerable proportion of the surface soils, and hence the soils and the topography which are dependent upon the underlying Tertiary strata, are never continuously or uninterruptedly characteristic over very large areas. The clay formations of the Hatchetigbee and Wood's Bluff, with the marl bed of the latter, cross the extreme southern points of Crenshaw; but we have seen only very few traces of their effects upon the soils, the overlying Lafayette sands and loam hiding them, generally, and limiting their surface outcrops to the vicinity of streams.

Soils.—The originally most fertile soils of Crenshaw are those which have been derived from the strata of the Cretaceous, in the northern part of the county. Even here the overlying sands and loam of the Lafayette temper and often obliterate the Cretaceous soils. Along the hill slopes and in some of the low grounds, however, we find the lime lands of Cretaceous origin, with characteristic timber, generally draped with the long moss. Over the area of the Tertiary the soils are prevalently sandy, and are not essentially different from the Lafayette soils, with which they are so greatly interlaced. The only prominent variation is in the short leaf pine belt of the Tuscahoma, and even in this we find, also, a great admixture of the Lafayette.

Useful materials.—Prominent among the mineral products of Crenshaw may be mentioned the Rutledge limestone, which is soft and easily quarried and dressed, when fresh, but which hardens on exposure just like the St. Stephens rock, which it otherwise very closely resembles. At many points about Rutledge it has been burned for lime, and Mr. Langdon also speaks of its use as a whitewash without being burned. Away from Rutledge this limestone varies very considerably from its description above, though Prof. Thornton, in Tuomey's Second Report, page 244, mentions the occurrence of the same white limestone on the banks of the Conecuh, where the Valleyton and Millville road crosses. This is on the eastern border of Crenshaw.

A very considerable amount of brown iron ore occurs in connection with the uppermost Cretaceous and the lowermost of the Tertiary series, but we know of no deposits of any commercial importance.

PIKE COUNTY.

The two upper tiers of townships of Pike county and nearly half of the third tier have as underlying formation, the *Ripley* of the *Cretaceous*. This formation here, as elsewhere, consists of alternations of gray micaceous sands and indurated sandy ledges of somewhat fossiliferous character. The prevailing sands are generally strongly calcareous, and where they form the soils these are quite fertile, and the trees are draped with the long moss. The topography of this section is somewhat broken and of the usual "lime hills" character. Patches of the Lafayette sands cover the summits of many of the hills and in such cases the timber is prevalently long leaf pine, and the soils show very little trace of lime. The extreme northern township of this county borders upon what has been called the "Chunnenugga ridge," which is the watershed between the Alabama River on the north and the Chattahoochee, Gulf tributaries on the south. This ridge is formed of the Cretaceous strata above mentioned, with the capping of Lafayette sands, and is a ridge of denudation, i. e., left by the removal of the adjacent strata. It extends from near Fort Bainbridge, in the edge of Russell, through the southeastern corner of Macon, diagonally through Bullock, through the upper part of Pike into the lower part of Montgomery county. It is best defined in Bullock, near Union Springs, which stands upon it. This watershed goes on through Montgomery and the eastern part of Lowndes, nearly along the border between the Rotten Limestone and the Ripley, but well into the latter. The slopes of this ridge towards the northward are as a rule quite abrupt and the contrast between the fer-

tile lime lands at the base and the sandy soils at the summit is very marked. The southward slope is usually long and gentle and covered with sands. Near the lower or southern limit of the Cretaceous, in this county, Mr. Langdon gives several sections especially in township 11, range 20, from which it appears that the Clayton limestone of the Tertiary overlaps for a good many miles the Cretaceous strata underlying. Thus in section 12 of township 11, range 19, not far below the northern line of the county he finds the Tertiary limestone (best exposed near Troy) capping the hills, and underlaid by some sixty feet of yellow sands, the result of oxidation of the Ripley strata named above, and below this a ledge of hard argillaceous limestone with the usual Cretaceous fossils. Southeast of China Grove Mr. Langdon records a considerable thickness of black laminated clays resembling strongly those characteristic of the lower Tertiary along the Tombigbee River, but here they are intercalated between the beds of gray micaceous sands of the Ripley.

Below the middle of township 10 the underlying formations are mainly the Clayton limestone and the Nanafalia sands and sandstones, the intervening members of the Tertiary being either absent altogether or making little or no show upon the surface.

The *Clayton* series, as it occurs in this county, is represented by gray glauconitic micaceous sands, with Tertiary fossils, 30 feet or more, and a limestone some 20 feet in thickness, with gray calcareous clays and gray sandy clays underlying. These and other beds of calcareous nature underlie a belt across this county some eight miles wide, in which the soils are generally derived from their disintegration, and are among the best in this section of the state. The soil is a red sandy loam or clayey sand, which supports a growth of hickory, white, red and post oaks, dogwood and black gum, with a few short leaf pines, all draped with long

moss, a very sure sign of fertility as well as of lime.

These red lands are seen from Henderson's Store towards Brandidge and thence northward nearly to Buckhorn, and back towards Troy again. Westward of this white sands cover very much of the country and the Tertiary soils are often hidden by it.

Below this belt to the border of Coffee county the rocks of the *Nanafalia* series underlie the surface. The most characteristic member of this series is a moderately hard sandstone, to which we have given the name of *pseudo-buhrstone* or false buhrstone, from its resemblance to the original buhrstone of the Claiborne formation. This rock occurs at the surface from section 25, township 9, range 20, down to Henderson's Store, at which place it is highly fossiliferous, as it is in the Grampian Hills of Wilcox.

The red lands above spoken of are found also over part of the Nanafalia territory as well as over the Clayton. Between these two principal members of the Lignitic Tertiary our Naheola series intervenes. While this makes very little show on the surface we may yet be pretty sure of its presence from the frequent occurrence along the limit of the Clayton and the Nanafalia of red sands with shells of *Turritella Mortoni*, and *Venericardia planicosta*, underlying a bed of fairly good brown iron ore. This same red sand may be seen at intervals at this horizon to the western border of the state near Rosser in Sumter county.

The Nanafalia rocks are easily recognized everywhere by the little oyster *Gryphœa thirsæ*, which is rarely absent from any of its outcrops.

The Clayton limestone in Pike county is massive enough to permit of the formation of caves and limesinks of considerable dimensions, and these are to be seen in places along its outcrop from Crenshaw county to the Georgia line.

Of *useful materials* we may mention the limestone, which at several places has been burned for lime; brown iron ore,

which results from the oxidation of a greensand marl occurs four or five miles southwest of Troy on the "Three Notch" Greenville road, and very probably at many other points in the same belt. This ore is rather silicious, and is hardly abundant enough to be of commercial value. Then on the border of the Tertiary and Cretaceous we always find a narrow belt of this ore, in other counties as well as in Pike. Here this iron ore occurs most abundantly in the vicinity of Josie post-office, between section 2, township 10, range 23, and section 27, township 11, range 23, and also in a southeasterly direction from Josie. In some places, according to Mr. Langdon, this ore covers three-fourths of the surface, and is of fibrous texture, "needle ore." This is the same in position as the deposit in Butler county near Dead Fall and Searcy Station.

In the Clayton formation heavy beds of massive clay are in places associated with the limestone, and may some day find application in the manufacture of tiles, terra cotta and the better grades of brick. Some clays in the region northwest of Troy are manufactured into ordinary pottery ware by Mr. Joe Babcock. The clay, according to Mr. Langdon, comes from the Lafayette formation, which at intervals occurs overlying both Cretaceous and Tertiary formations.

The indurated strata of the Nanafalia formation, our *pseudo-buhrstone*, which occurs in the lower part of Pike is extensively used as a chimney rock, being easily worked and sufficiently durable and fire proof.

HENRY COUNTY.

The extreme northeast corner of Henry is underlaid by the strata of the Ripley division of the Cretaceous, while the rest of the county is made by the strata of the Tertiary from the Clayton up to the White Limestone inclusive. In addition to these, the Lafayette, the Ozark sands, and the Second Terrace deposits from a good proportion of the surface.

The *Cretaceous* forms so small a proportion of the surface of Henry as to need no special mention since it is merely the continuation of the formation so well represented in Barbour under which head full details will be found.

The lowermost division of the Tertiary, the *Clayton* limestone is also concerned in the formation of the northeastern part of the county. This division, while it does not make much of a surface show, is yet important for the reason that some of the best farming lands of east Alabama are based upon it. Over a great part of the territory of the Clayton, the soils are deep red colored loams, which support a vegetation of black jacks, red, post, and Spanish oaks, hickories, short leaf pine, (and in sandier places, the long leaf pine), chestnut and sour gum, with long moss upon most of the trees. This all points to the influence of the underlying calcareous formations upon the surface soil. In this region limesinks also give evidence of the presence of the limestone below.

Along the border of this formation with the Cretaceous, it is usual to find very fair quality of limonite or brown iron ore, though probably not in large quantity.

The narrow belt underlaid by the *Nanafalia* division, shows nothing peculiar. The topography is generally somewhat broken and hilly, and the long leaf pine is the prevailing growth, though there are places where the soil is red, and the growth is prevalently of the upland oaks and short leaf pine. The belt of the *Tuscahoma* is particularly distinguished by the growth of short leaf pine and oaks, although the overlying Lafayette obscures this feature and furnishes the soils. The *Wood's Bluff* and *Hatchetigbee* do not make much surface show here, unless in the hilly character of the topography. Half way between Lawrenceville and Abbeville there is a shell marl exposed which is probably the representative of the Wood's Bluff horizon. On account of the covering of Lafayette over all this part of Henry it is rarely that we can see sections of the underly-

ing Tertiary rocks. Near Lawrenceville the Tertiary strata are bluish sandy laminated clays, the exact horizon of which it is impossible to determine with certainty, though they probably belong to the Nanafalia series. So also on the Choctawhatchee river west or southwest of Lawrenceville, similar gray laminated clays form the banks.

About four miles north of Abbeville the pine hills set in with the first outcrops of the *Buhrstone* formation, and this formation makes the country thence for twelve or fifteen miles. In a great part of this wide belt through Henry the country has the characters of the long leaf pine hills, but there are many places where the watersheds and plateaus are capped with a bed of red loam resting on pebbles, of the *Lafayette* formation and the country is more attractive. Where sands and pebbles make the immediate surface as in the vicinity of Echo, the timber growth consists of stunted barrens oaks, viz., the black jack, the turkey oak and the upland willow oak, along with some small long leaf pines.

About Abbeville, the strata presumably of the Buhrstone horizon are exposed in the gullies underneath the covering of sand and pebbles of the Lafayette age. These Tertiary strata near the town are bluish sandy clays without any fossils by which the age may be determined, but a few miles west of town the indurated rocks of the Buhrstone occur and have been quarried for the purpose of obtaining materials for the construction of chimneys. Here the rock contains shell casts in abundance. Two miles north of the the town also, there is an outcrop some six inches thick of a buhrstone-like rock with root like concretions of clay and a few obscure shell casts. On the road from Abbeville towards Echo, the Buhrstone is seen six miles from the former place and near Cureton's Bridge, also below the junction of the two Judah Creeks and elsewhere in Dale county. West or southwest of Abbeville the Tertiary beds consist generally of light gray laminated clays interstratified with reddish cross-bedded sands.

Crossing the country in the latitude of Headland, Pleas-

ant Plains and Columbia there is a belt of fine farming lands occupying about the position of the outcrop of the Claiborne formation, but the soils appear to be derived entirely from the Lafayette materials and are generally red sandy loams with an underbed of pebbles, This belt which is somewhat undulating rather than hilly supports a growth of long leaf pine and the usual upland oaks. Most of the land is under cultivation and the farms and houses are well kept. To the south of this lies the region of the open piny woods with limesinks, underlaid by the strata of the *St. Stephens White Limestone*, which by reason of an undulation already mentioned, keeps at or near the surface for many miles. In this region the prevailing growth is the long leaf pine often with little or no undergrowth but it is interspersed with limited areas in which the upland oaks are abundant. and in such cases the soils are more or less loamy in character and in contrast with the sandy soils of the open pine forests.

Over much of this area the limestone is exposed at the surface but rarely retains much of its original calcareous matter, which has been almost completely replaced by silica. In consequence, it has little or no beneficial effect upon the soils. In the banks of Omussee creek below Columbia and extending up the creek for five or six miles, are exposed some ten or fifteen feet of calcareous sands with ledges of indurated calcareous clay of greenish yellow tinge. These are the representatives of the lower beds of the St. Stephens White Limestone as may be inferred from their position which is clearly exhibited near the mouth of the creek, for here we find immediately below these clayey sands, yellow sands holding great numbers of the shells of *Ostrea sellæformis*, and hence of Claiborne age. A mile or two above the mouth of the creek and just across the bridge over which the road passes towards Gordon, the limestone with great numbers of *Orbitoides Mantelli*, a characteristic fossil of the White Limestone occurs overlying the greenish clayey sands seen in the creek banks. At this place the

limestone is in part silicified, and in part of its original composition and has been burned for lime. The outcrops of the various Tertiary formations along the river banks have been described by Mr. Langdon, and his descriptions need not be repeated here.

The post-Tertiary formations occurring in Henry county are of interest as being somewhat typical of this southeastern part of the State.

Under this head I include the *Lafayette* which may be latest Tertiary, but which allies itself in structure and distribution with the post-Tertiaries. Here as elsewhere the Lafayette consists mainly of sands varying extremely in the size of the grain, but always well rounded and water-worn. False bedding is a common feature of its structure. It passes upwards into a red loam which lies usually upon the upper terrace of the river, and caps the hills lying between the principal streams. In Henry county one may see at many points the red loam with underlying pebbles capping these dividing plateaus, 30 to 40 feet in thickness, and going down the slopes towards the streams and at 100 feet lower level, the same materials in the same thickness and with the same structure, especially as regards the cross-bedding, as if originally deposited as a sort of blanket over an eroded surface of the older Tertiaries. The third terrace of the Chattahoochee is a conspicuous example of this low level phase of the Lafayette, and it is beautifully exhibited at the town of Columbia and on the river road between Columbia and Gordon, which follows this terrace. The whole aspect of the country is precisely similar to what may be seen far to the north, even up to the latitude of Tuscaloosa. Upon many of the high ridges or divides capped with the Lafayette, pebbles of limonite are abundant, representing in the aggregate a very considerable amount of iron which is, however, too scattered to be of service.

The terraces of most of the creeks in the lower part of this county are made of gray sands, which also spread over the divides up to altitudes of 100 feet or more above the river level. The same or precisely similar sands make an upper

second terrace, a few feet higher than, and lying to the land ward of the regular second bottom terrace of the river. In the lower part of these sands, especially on going down the slopes towards the streams, small pebbles are sparingly disseminated. Along the Chattahoochee River the *Second bottom* terrace is well displayed in a bench which will average, perhaps, a mile in width and upon which are located some of the best farms in the county. It has here the usual characters, a light yellow clayey loam at the surface eminently fitted for the making of brick, with sands underlying, down to the water level. At many places interstratified with the sands, we find a bed of blue clay containing vegetable remains in the shape of bituminized trunks, stumps, etc.

Of *useful materials* afforded by the geological formations may be mentioned the building stone of the Buhrstone formation so extensively used in the making of chimneys and pillars of houses. The marl bed of the Wood's Bluff horizon would be of service to the fields if only systematically used thereon.

The limestone and its silicified representative, of the St. Stephens group, is also extensively used for the same purposes as the Buhrstone and is much more widely distributed. In some places it has been burned for lime. The silicification above mentioned appears to be a surface phenomenon, for the limestone when brought up out of wells is very little changed and is tolerably pure carbonate of lime.

DALE COUNTY.

In its geological structure this county resembles its neighbors, Coffee and Henry. In its northern two-thirds, it is based upon the strata of the lignitic division of the Tertiary from the Nanafalia up. In the southern part the beds of the Claiborne come in and are in turn succeeded by the St. Stephens White Limestone. Two later formations, the Lafayette and the Ozark contribute very materially to form the immediate surface.

The *Nanafalia* series occupies a small area in the northwestern corner of Dale where Mr. Langdon gives a characteristic section of its strata as follows:

Section of Nanafalia Strata.

1. Indurated sandy claystone, *pseudo-Buhrstone*.....10 feet.
2. Light yellow sand becoming red and slightly calcareous on descending.....30 feet.
3. Black lignitic clay (supposed to be the representative of the Landrum's Creek lignite of Marengo).....8 feet.
4. White sand..... 2 feet.

To the southward of this follows the *Tuscahoma or Bell's Landing* series of clayey sands and marls. These may be seen along the road from Blue Springs in Barbour to Skipperville, and thence down to Judah Creek. The most frequently seen rock is a sandy clay which closely resembles some phases of the Buhrstone. In the banks of Judah Creek at Bottom's Mill this stratum is found to be fossiliferous, the only well preserved forms being an oyster which is exceedingly friable and difficult to get out, and large shells of turritella, probably *T. Mortoni*. These beds do not have much influence upon the soils because of a heavy covering of the Ozark sands.

The *Wood's Bluff* and *Hatchetigbee* series makes very little surface show in Dale County. Mr. Langdon has described a section on West Choctawhatchee on the road from Abbeville to Skipperville, which may be referred to this horizon, but it shows nothing characteristic. The rather broken country to the northward of Ozark and southwestward from Skipperville is probably caused by the strata of this series.

The *Buhrstone* underlies a belt across Dale County from six to twelve miles wide, in all of which the aluminous sandstone which is so characteristic of the formation, may be seen at almost any of the points where roads cross the creeks and streams. Ozark is situated near its northern border, and Newton near the southern. Everywhere it is used in the construction of chimneys and pillars. It does not, as a rule, form the immediate surface away from the

borders of the streams, for it is like most of the Tertiary formations of this section of the state covered either by the Lafayette or the Ozark sands or by both. Where not so covered, this formation and the next succeeding one, the *Claiborne proper* form some of the best farming lands of southern Alabama. Such a belt of good lands for instance extends with little or no interruption from Daleville and perhaps further west, out by Newton eastward to the line of Henry. The soil here is a red sandy loam, which may be in good part based upon the loam of the Lafayette, but the tree growth indicates at many points the underlying calcareous formations.

The Buhrstone forms the country about Ozark, thongh covered there both by the Lafayette and the Ozark sands. In the railroad cut just north of the town there is a section exposed as follows :

Section in R. R. Cut, Ozark.

1.	Gray Ozark sands	3-4 feet.
2.	Red clayey loam (Lafayette)	6-8 feet.
3.	Light colored laminated clay	5 feet.
4.	Dark bluish pyritous sands	5 feet.
5.	Black laminated or joint clay	3 feet.
6.	Greensand filled with shells mostly a species of *cytherea*, but other forms recognizable	5 feet.
7.	Black sandy clay to botton of cut	4 feet.

The southeastern part of Dale is made by the St. Stephens limestone, very generally silicified, and often to the extent that silica has replaced the lime carbonate completely, so that the rock no longer effervesees with acids. The whole territory underlaid by this formation is gently undulating and is timbered with long leaf pine with the varieties of upland oaks, but principally the black jack. Limesinks and ponds at frequent intervals reveal the presence of the limestone at no great distance below the surface, although it very rarely has any effect upon the soils.

Over some of the territory of the Buhrstone there are overlaps of the St. Stephens limestone reaching in many in-

stances several miles to the northward of its normal limit. Mr. Langdon mentions one such outlier of the St. Stephens limestone (in this instance more or less silicified, as is so frequently the case in these southeastern counties) a short distance below Clintonville, five or six miles. Reference has been made in another place to the fact that there is a flattening of the dip, or rather an undulation in the Tertiary formations in the lower part of the State by which they are brought into nearly horizontal position for many miles. In such cases the formation, or rather the leaving, of outlying masses of the St. Stephens which is the uppermost of the Tertiary series here, is merely a matter of denudation.

The sands and loam of the *Lafayette* with its beds of pebbles have at one time probably covered the whole of the Tertiary formations of Dale, but these coatings have been removed in many places but are still very generally met with upon the divide between the main water courses. In many places the pebbles are abundant and large.

Another surface formation of later date than the Lafayette we have designated by the name of *Ozark or Geneva* from its characteristic occurrences at both these places. The principal material of the Ozark series is a gray sand which about Ozark is some four feet in thickness, and overlies the red loam of the Lafayette. This sand is very unevenly distributed not only in Dale but in the adjoining counties. In Dale we see a patch of it about Skipperville, also another about Ozark which extends southward for several miles. We have not yet had the opportunity of marking accurately the boundaries of these sands. In Geneva they cover considerably more area. Along most of the creeks of this and Geneva counties and along many in Henry and Barbour we find these gray sands forming a kind of terrace just outside of and slightly higher than the regular Second bottoms. Along most of the minor creeks it replaces the second bottoms entirely.

Of *useful materials* there may be mentioned the sandy aluminous beds of the Buhrstone which are so extensively

used in building chimneys, and a very similar material belonging to the Nanafalia series in the northwestern corner of the county.

The silicified limestone of the St. Stephens group is also used for rough building purposes, but it is never dressed, but used in rough mass just as it is gotten up. Where the St. Stephens rock is unaltered it may by selection be used in making lime, but I do not know of any place in Dale where it has been so used, though doubtless there are many.

In the northern edge of Ozark the railroad cuts expose a *shell marl* which belongs to the Buhrstone horizon, (see section above.) This marl, which contains a good quantity of phosphate of lime might very advantageously be used upon the soils around Ozark and inasmuch as it occurs where it might be dug out and loaded upon wagons, or upon the cars with very little trouble and expense it seems strange that advantage has not been taken of it.

GENEVA COUNTY.

The area of Geneva is 590 square miles, and of this nearly the whole or about 570 are underlaid by the strata of the White Limestone, while along Pea River, Double Bridges Cr., and Choctawhatchee river there are perhaps 20 square miles where the underlying Claiborne beds come to the surface. Over these Tertiary beds, which make the substratum of the county, there are thick beds of sand, loam and pebbles, belonging to the Lafayette formations and to the Ozark and Geneva sands.

Tertiary.

From what has been said it will be inferred that the Tertiary formations though underlying the whole county, do not as a rule make the surface, which is occupied by the later deposits named. As a matter of fact, we see the White Limestone and Claiborne beds only in the vicinity of the creeks and rivers where the overlying sands and loams have

been removed by erosion. The Tertiary formations while having a general dip of 25 or 35 miles to the south, do not always preserve this dip, for in many places we are able to discover undulations or rolls which cause them to remain at or near the surface, where with uniform dip they would be many feet below the surface. This is well illustrated in Geneva in the case of the two Tertiary formation concerned in its structure.

The regular normal outcrop of the *Claiborne* as may be seen by the geological map, lies to the north of the borders of this county, yet it comes again to the surface far south of that and even to the very southern limit of the county, along the rivers above mentioned. In a general way the presence of the White Limestone below is indicated by the limesinks which are common through most of the county. Wherever the White Limestone is exposed it has been subjected to the action of silicious solutions which have completely altered it, so that it contains little or no limestone but is almost completely silicified. Such for instance is the case along Double Bridges Creek and Pea River in the vicinity of Geneva.

Five or six miles above Geneva on Double Bridges the bed of the creek shows a sandy glauconitic limestone which also makes the banks up to 5 or 6 feet above low water mark. The uppermost layers of this rock contain a great number of the shells of *Scutella Lyelli*, which is characteristic of the upper Claiborne. Over this are a few feet of loose calcareous earth with many *pecten* shells, evidently the disintegrated remains of a somewhat similar rock to that just described. This in turn is covered by the gray sands of the Geneva or Ozark age, which form all the level flat of the creek, the intermediate Lafayette being here carried off by previous erosion. In the banks of the Pea River just below Geneva, and near the confluence of the Choctawhatchee, there is an analogous exposure of the upper part of the Claiborne consisting of the glauconitic sandy limestone above mentioned with some ledges of purer yellowish

limestone. About 10 feet thickness of these rocks may be seen at the edge of the water, the whole being capped by the stratum with the *Scutella Lyelli*, while the lower parts of the limestone hold many shells of *Ostrea Johnsoni*, and *Ostrea sellæformis*, which are generally thoroughly silicified and much corroded by the action of the water.

Overlying these Claiborne strata in one or two localities, 30 to 40 feet thickness of bluish gray calcareous clay may be observed. This clay appears to be devoid of fossils, and from its position it has been assigned to the *Jackson* or lower division of the White *Limestone*, for above it at the base of the hills a short distance away from the immediate river banks, the *orbitoidal* or Vicksburg limestone appears in good exposures. As usual in this section of the state these rocks have been more or less completely silicified. Fragments have rolled down the inclines and are now to be seen along all parts of the river banks, but always in loose pieces, since these rocks do not as a rule form the immediate banks of the streams, but occur at the base of the hills a short distance back. The silicious rocks above mentioned take on two forms; in one condition they are hard and compact sandstones, in the other soft, floury, and easily crumbled; in both cases the carbonate of lime of the original rock seems to have been almost completely replaced by silica. That this replacement is a surface phenomenon is made probable by the circumstance that in all parts of the county, there are numerous limesinks and ponds showing limestone below. For a good many miles west of Geneva and in the northwestern part of the county, the Claiborne beds with *scutellas* and *pectens* are exposed in a thickness of nearly 20 feet in the banks of Pea river near Elton, and the same beds are also seen in the bottom of Flat creek on the road towards Lakeview.

The *topographical features* of this county are those of the southern tier of counties generally, gently undulating

lands, with numerous depressions formed by limesinks, in some of which water has collected forming lakes, ponds, or swampy places. The surface is generally covered by sands of the Ozark or Geneva age; the timber is chiefly the long leaf pine. But there are many places where the upland oaks are associated with the pine, where the capping of Geneva sands is not so thick as to place the underlying Lafayette too far below the surface to be reached by the roots of the trees.

In the eastern part of the county along the drainage area of Big Creek there are occasional spots where the calcareous clays of the lower part of the White Limestone are near enough the surface to affect in a favorable manner the quality of the soils. Also in the vicinity of Dundee there are tracts of oak and hickory uplands with the long leaf pine, but as a rule the soils are sandy and the growth long leaf pine without much admixture of other growth.

COFFEE COUNTY.

Coffee county is based upon the strata of the Tertiary formation, from the Nanafalia of the Lignitic up the White Limestone which makes a narrow strip along the southern border. The *Nanafalia* which forms the upper tier of townships consists here as elsewhere of sands and indurated claystones with the fossil, *Gryphæa thirsæ*. The indurated rock is the false buhrstone used everywhere in the region of its occurrence in building chimneys and pillars of the houses. The topography of the Nanafalia is usually gently rolling, the prevailing timber is the long leaf pine and the country underlain by it is popularly known as "rolling piny woods."

The *Tuscahoma* series of sands and marl makes a belt through Coffee county six or eight miles wide occupying all the second tier of townships, and a small part of the third. The characteristic gray sands which have a strong tendency to indurate at intervals into rounded bowlder-like forms,

may be seen in the banks of Pea river above Elba and thence up to Cole's bridge. The strip of country formed by these strata is generally clearly marked by its topography and timber growth. The prevailing soil is a reddish clayey loam which supports a growth of short leaf pine with post and Spanish oaks. In places this uniformity is interrupted by patches of more sandy soils with long leaf pine as characteristic tree, and generally these soils are derived from the materials of the Lafayette surface formation.

Just south of Elba there is narrow strip of hilly lands formed by the clays and marls of the *Wood's Bluff* and *Hatchetigbee* formations. This strip extends across the county nearly east and west and has a red soil with some admixture of clay. The timber upon these red clay hills consists of short leaf pine, Spanish and red oaks and hickory, with festoons of long moss in the better spots. At times the long leaf pine is also abundant. These hills are very generally in cultivation and are productive. In the banks of the river below Elba as far as Churchwell's Bridge, Mr. Langdon finds the Wood's Bluff and Hatchetigbee strata well displayed in a series of yellow and gray sandy clays with fossiliferous layers at intervals, filled with the peculiar fossils of the Wood's Bluff type, and below these, laminated gray clays the representative of the Hatchetigbee series. These exposures are described in the article which Mr. Langdon contributes to this report and need not be repeated here in detail. At Kimmey's Mill about 6 miles below Elba, the same Wood's Bluff beds may be seen, where they consist of bluish clays alternating with beds of greensand marl containing the Wood's Bluff shells. In the eastern part of the state the Tertiary formations do not so directly influence the soils and topography as they do further west, for the reason that here there is a greater prevalence and thickness of the sands of overlying formations than there. While the Wood's Bluff and Hatchetigbee formations in Choctaw, Clarke, and Mon-

roe, form very characteristic lime hills, i. e. clay hills strongly marled by the Wood's Bluff beds, further east this character is almost lost, but by careful examination the continuity has been traced across to the Chattahoochee. We see, however, east of Butler county none of the clay hills proper, but instead a hilly region with red clayey sand soils. The influence of the marl is, however, felt to the Georgia border and is indicated by the draping of long moss on the trees.

To the southward of the narrow hilly streak we come upon the territory underlaid by the strata of the lower *Claiborne* or *Buhrstone*. These being as a rule sandy do not influence the soil for good, and the whole region is a pine forest, now sadly stripped. Fifteen years ago I crossed it going from Geneva to Elba, without passing a human habitation; now it is pretty generally settled up. This refers to the ridge road between Double Bridges and Pea river, for even fifteen years ago there were many good farms lying in the vicinities of the river and creek. The Buhrstone strata make little if any show upon the surface, but in the river banks they crop out for many miles below Churchwell's Bridge as shown by Mr. Langdon. The indurated claystones characteristic of this formation occur in the river banks in the form of ledges 15 to 20 feet thick, alternating with yellowish glauconitic and calcareous sands.

Near the border of Geneva county the Buhrstone series is succeeded by the strata of the upper Claiborne or *Claiborne proper*, yellowish calcareous sands and gray calcareous clays containing the characteristic fossils, chief among which is an oyster, *Ostrea sellæformis*. By reason of an undulation of the Tertiary strata here, these Claiborne beds do not sink permanently below the surface till below the Florida line, being well exposed in the banks of the river at Geneva, and presumably all through Geneva county. The Claiborne beds, like the Buhrstone, do not make themselves felt in the soils nor in the topography, principally because of the mantle of sands overlying all the Tertiaries of the lower part of the state, and to which reference will be made below. In the

lower edge of Coffee there are patches of the *St. Stephens* or Vicksburg White Limestone occurring at elevated points in the latitude where the Claiborne beds are seen outcropping in the banks of the creek and river. In a word we have in the lowermost border of Coffee the beginning of the conditions which hold entirely through Geneva county.

The *Lafayette* sands and red loam occur at intervals over the county covering the Tertiary substratum. In this part of the state this formation is inclined to be rather more sandy in its nature and more micaceous than further towards the west. In many parts, especially in the lower part of the county, it is in turn covered by sands of a later age, viz., the *Ozark* or *Geneva sands.* A part, if not all of the Buhrstone terrace, is thus doubly covered. Where the Ozark sands are untempered by mixtures either with the Lafayette or with the underlying Tertiary formations, they form soils of little promise or possibility, which support a growth of the barren oaks and stunted long leaf pine. All the valuable pine timber has for its favorite soil the sands and loams of the Lafayette. To recapitulate concerning the soils of Coffee, the northern row of townships form rolling piny woods, with the Nanafalia sands and the overlying Lafayette sands for their basis. Below that the belt lying to the north of Elba with its red sandy soils and short leaf pine and upland oaks. Then the red hills of the narrow belt below Elba, succeeded by the level or gently undulating pine lands of the Buhrstone, and in the extreme south, an occasional outcrop of the St. Stephens limestone, in all this section of the state, now completely silicified.

Of *useful materials* to be derived from the geological formations in Coffee there are few. The false Buhrstone of the northern part of the county is used for building purposes, and the same may be said of the true Buhrstone where it exists in beds of sufficient thickness, and easily accessible. I have, however, not noticed any use made of it in Coffee county. The silicified St. Stephens limestone, which is also called Buhrstone, has been made into millstones in some sections, but not, so far as I aware, in this county.

COVINGTON COUNTY.

By the map it will be seen that Covington is divided nearly equally between the Claiborne and Buhrstone on the north and the St. Stephens White Limestone on the south, although narrow strips of other formations are added, viz., the Hatchetigbee and Wood's Bluff in the extreme north and the Grand Gulf in the extreme south. None of these Tertiary formations, however, make much show on the surface, which is occupied almost universally by the materials of the Lafayette. The Tertiary outcrops are therefore confined to the vicinity of the water courses and to places from which the overlying Lafayette has been denuded.

The *Hatchetigbee* and *Wood's Bluff* divisions of the Lignitic occur along the northern border of Covington, especially where the sands of the Lafayette have been thinned or removed. They may be recognized by the prevalence of calcareous clay soils and a better class of timber growth, oaks and hickories mingled with the long leaf pine. This forms a continuation of what is known as Oakey Streak in Butler county.

To the southward of this northern border of the Lignitic the country for eight or ten miles is underlaid by the strata of the *Buhrstone* or *Claiborne*, neither of which, however, occurs very generally upon the surface.

Many outcrops of the Buhrstone have been noted by Mr. Langdon in the article contributed by him, especially along Conecuh river from near Hamptonville down to Bullock's Bridge. A short distance below the last named locality Mr. Langdon describes an outcrop of the Claiborne shell-bearing formation. In this northern half of the county the topography is rather more broken than in the lower and there is a greater prevalence of oaks and other hard woods among the pines. In the northwestern part of Covington east of Vera Cruz and thence towards Andalusia the road passes for some distance along a high pine ridge with very sandy soil, the topography being due to the underlying Buhrstone. East

of Andalusia towards Churchwell's Bridge below Elba, the country for ten miles is hilly and broken but timbered with Spanish and post oaks along with the long leaf pine; the soil being a dark reddish loam with considerable admixture of clay. Thence to eastern border of the county the lands are mainly level or gently rolling piny woods. This is along near the lower edge of the territory underlaid by the Buhrstone. West of Andalusia the country is undulating for some miles, then descends towards the river, beyond which it is again elevated rolling piny woods with little or no undergrowth. To the northeast of Loango, about S. 2, T. 4, R. 14, and thence to S. 38 of the township above it, the road passes over a very broken, almost precipitous country with very little long leaf pine, but with short leaf pine and the upland oaks as characteristics. An overlap of the Grand Gulf sandy clays is recorded here both by Mr. Langdon and Mr. Johnson, and an inspection of the map will show a northward extension of the St. Stephens also up on the divide between the Conecuh and Pigeon creek.

In the lower part of the county which is underlaid by the *St. Stephens* and the *Grand Gulf*, the surface is gently undulating or rolling, and the forest generally of long leaf pine. The limestone rarely shows at the surface but its presence is known by the occurrence of limesinks which in places are filled with water and form ponds and lakes, the most notable of these in the county is McDade's Pond which lies on the border of the county with Florida. The natural drainage of this lake is into Pond creek towards the south, but a canal has been cut near Lakeview by which the waters of the pond have been led northward into a tributary of Corner creek; this for the purpose of supplying Mr. Hughes' mill.

Exposures of the strata of the White Limestone may be seen at many points where the Lafayette sands have been removed by erosion, as, for instance, along the tributary streams of Conecuh and Yellow Rivers. Mr. Langdon has described one such occurrence near Loango, in the lower

part of T. 5, R. 14, which shows, however, nothing of particular interest. The same strata form the banks of Conecuh River, just above Mason, and at a short distance from the river the level piny woods between Mason and Rome show many limesinks and ponds indicating the presence of the limestone below. Near the confluence of Five Runs and Yellow River there are numerous exposures of this formation. At the bridge over Five Runs we see some 20 feet of the calcareous clays and argillaceous limestones, with abundance of fossils, which are chiefly *pectens* and *orbitoides*. At the bridge over Yellow River, in the northwestern corner of township 1, range 16, very similar strata are exposed in the river bank, and Mr. Watkins reports the finding of bones, probably of the *Zeuglodon*, at the same place.

In section 5 of the same township and range, there is a fine limestone spring gushing out from below the limestone ledge. This spring furnishes the supply for the mill of Mr. Watkins, and runs off in a stream of very considerable size. In the two lower tiers of townships in Covington the Ozark or Conecuh sands have been spread over all the Tertiary rocks and form the surface generally all across the county, except along some of the more elevated divides, as below shown. The timber in all this region is the long leaf pine, with very little admixture of other trees; the soils are sandy and the habitations of men few and far between, especially along the high roads which follow the low uplands. About eight miles to the northwest of Lakeview the divide between the waters of Yellow River and Pea River is a low ridge some 50 or 60 feet elevated above the water courses. This ridge has for its surface soil and for subsoil the red, sandy loam of the Lafayette formation, and much oak and hickory along with the long leaf pine. This oak upland region is two or three miles across. On descending towards the west the piny woods set in again, and the oaks disappear, except the black jack, and the Ozark sands again form the surface, as they do in the southeastern part of the county.

The extreme southwestern corner of Covington is probably underlaid by the strata of the Grand Gulf, though none of these strata have been actually seen further east than Roberts, on the Conecuh. They would, however, escape observation except along the water courses, where the conditions were specially favorable, and they exercise no influence upon either the soils or the topography, which are determined by the two surface formations—the Lafayette and the Ozark sands; the latter in the lower tracts, and the former over the divides fifty or sixty feet elevated above the water courses.

Soils.—From what has been said, the distribution of the soil varieties may be inferred. By far the greater part of the soils are from the materials of the Lafayette, except in the southern part, where the Ozark sands make their contribution. In the extreme north the Lafayette sands and loams are tempered by admixtures with the clayey strata of the Lignitic; but this admixture occurs only in spots where denudation has exposed the underlying strata. The territory underlaid by the Claiborne and Buhrstone is a rolling, upland country generally, timbered with oak, hickory and pine, and contains much very fair land. Such is the country traversed, for instance, between Elba and Fairford. The soils over the rest of the county, towards the south, are disposed to be more sandy, with a timber more exclusively of long leaf pine, and particularly at moderately low levels along the southern border, where the Ozark sands prevail. Even in this section the divides and more elevated ridges, being above the level attained by the sands above named, have the red loam and other strata of the Lafayette at the surface and are responsible for the soils.

Forests of excellent pine timber cover very large areas in Covington, but the inaccessibility has interfered with its utilization. The opening of the railroad from Troy to Brewton will make available much of this timber.

The *useful products* from the geological formations are not numerous. The Lafayette furnishes sand and gravel for va-

rious purposes, and also some rough, ferruginous sandstones which may be utilized in building. Clays, also, for brick making, are to be had in the same formation. The Buhrstone and the St. Stephens Limestone yield a rock which has, in places, been much used in the building of chimneys, and this is especially true of the soft limestone of the latter formation, which furnishes the material for the chimneys through all the region of its occurrence. In the Claiborne, as well as in the St. Stephens, there are shell marls that might be used with great profit upon the lands, though they do not, as a rule, contain any considerable quantity of phosphate, and their value would be dependent, almost solely, upon the lime which they carry. Bold springs of clear, blue limestone water issue from below the bluffs of the limestone in many places.

ESCAMBIA COUNTY.

(L. C. J.)

Tertiary.—There can be no doubt, all of this county, except, perhaps, the extreme northeast, on Sepulgah River and Bottle Creek, with a little on Cedar Creek and in the fork of Conecuh River, is to be included in the *Grand Gulf* terrace. It becomes exceedingly interesting to watch the indications in the northern part of this county, and the southern part of Conecuh, as they change first in favor of Eocene Marls, and then declare the prevalency of these intractable, clayey sands. On Burnt Corn Creek, on Juniper and on Murder Creek almost to Brewton, there are ponds and circular depressions in the piny woods indicative of a lime formation at no great depth beneath. A moderate depth may be one hundred feet; and if it indicates the near presence of calcareous marls, in which underground rivers may exist, to account for the sinks, it also as clearly announces the presence of a tough, overlying rock or clay formation, capable of checking the depression and holding the rain waters. The Lafayette could not do this, and all of the exposures go to show that its development in this region is but

moderate. The Grand Gulf, we have seen, therefore, in the northwest corner, coming into the county from Baldwin, Monroe and Conecuh, must be regarded as the main builder of this county. As it first crops out in Baldwin county, on the border, it has been described under the head of that county. A little farther eastward it takes another phase. The lands begin to lie lower and many ponds are developed; a little more sand covers the surface and spots become capable of cultivation. At Steadman's, on "Pack's Springs," there are considerable settlements. But these are separated by wide strips of low slashes and savannas, indicating the near presence of underlying clays.

On the Escambia River it is probable that a careful search would discover many exposures, but the uneducated eyes of the average citizen have not remaked such things, and the travelling geologist may not have time to search for them. As it is, the most important discoveries are often lighted upon unexpectedly, without previous information from the inhabitants. An instance was the happening on the "Big Cut" west of Flomaton. Here, beneath a moderate thickness of the Lafayette, are 20 feet or more of these clays. According to the best judgment to be formed from an isolated group without fossils, it may be assigned to the Pascagoula formation. And no other interpretation can be given of the extensive tract of fine red lands northward of this, at Canoe Station, and some of it northeast of Williams, but that it is an overlap of the Pascagoula. On Escambia Creek, or the Little Escambia, farther east, the deposits of the Lafayette and gravel be come deeper, and the bottom of the Railroad cuts not so decided.

Pollard, upon Conecuh, is located on a "Second Bottom" terrace, only 80 feet above tidewater, but the underlying formation is Pascagoula or Hattiesburg Grand Gulf, and was probably much degraded before the newer deposits were laid down. The most interesting fact to notice is success in boring for water. At 70 feet a flowing head was struck with a pressure capable of forcing the fountain 30 feet above the

surface. Forty-one feet at the boring of one of the wells was through a greenish blue gray clay precisely to that washed from the wall at Biloxi, Mississippi, at 800 feet. Borings at Brewton have also been made with like success. First water was obtained at 46 feet, and greatest flow at McGowan's Stable at 84 feet. At Dr. Malone's, lime rock (Eocene) was reached at 153 feet. At the ferry on the Milton road below Pollard, the bluff of Second Bottom sand is less than 30 feet above the low water mark, at which greenish gray clay is seen, and probably forms the river bed for miles up and down. At the crossing of Conecuh is the last very decided outcrop of the Grand Gulf clays going eastward to be seen in Alabama or Florida on this road. On the south or left branch of Conecuh, following it up, at Douglasville, you cross Mayor's creek, and a few miles further, Silas creek is crossed also, on a high bridge. On the northern bank is the old Jenkins place, once a prosperous farm.

The cedar, oak and magnolia woods indicate an outcropping of a better soil material than ordinary Grand Gulf clay or Lafayette. The head of the creek, a mile above, at Roberts' P. O., shows the semi-calcareous clays and lignites of Coal Bluff on Conecuh, with the obscure fossils described elsewhere. According to information of intelligent gentlemen residents in the vicinity, all the smaller creeks cut down to whitish or gray clay before entering the river, but none of them expose rocks nor has any one seen fossils, except the shells at Roberts and the lignite at Coal Bluff. The wells are in sand all the way to 60 feet and get good water.

Lafayette.—The character of the Lafayette in this county on the two Escambias and on Conecuh, is wholly unlike that in the southern parts of Mobile and Baldwin. It is finer, looser, and whiter. It contains less clay and less ferruginous matter. As in the western counties however, it gets deeper to the south, is thinner at the north. Near the southern boundary of the county runs the L. and N. R. R. with many cuts from Perdido Station to Flomaton, which

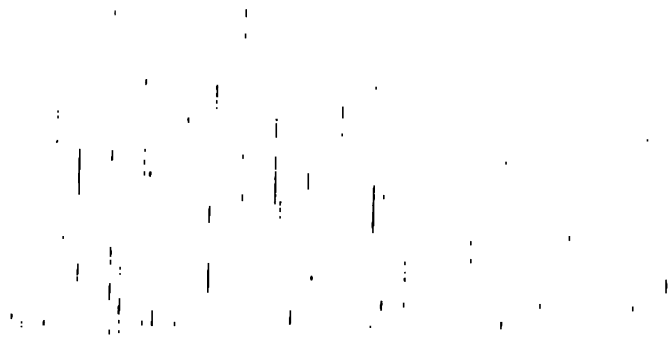
well expose Lafayette structure at places. At Williams Station wells 60 feet obtain water in gravel. The R. R. profile gives the elevations at Williams, 297 feet, at Canoe, 302 feet, and at another deep cut further east, 301 feet. Hills in the vicinity of Canoe are considerably higher. All this ridge between Perdido Bay and Escambia River and Bay is a repetition of the ridge of the middle of Baldwin county. The elevations are not quite so high, and it does not reach quite as far south, but it does extend southward to within three miles of Pensacola. The L. and N. R. R. Branch passing over the edge of it, still find elevations, at Flomaton 96 feet, at Cantonment 171 feet, at Pine Orchard 156 feet, at Bowes (last above Pensacola) 119 feet, and at Pensacola, at upper end of town, it is 30 feet.

Second Bottom.—This formation is not extensively found in Escambia. Alluvial deposits are too insignificant to mention. Though moderate in amount, the "Second Bottoms" are important in agriculture because sustaining a large part of this industry; it has or had once the largest pine timber of the long leaf species (P. Australis); it is under this by means of wells that the Grand Gulf clays are so easily discovered; it is has been to us therefore important geologically. Second Bottoms are generally well developed on both the Escambias, on Burnt Corn, and on Murder Creek, as on all the larger water courses; and on Conecuh are thought to extend through the county, and into Florida to Escambia Bay and to Pensacola City. The third bench or Ozark Sands (i. e. Columbian) is more extensively spread out than the second terrace, and exceeds in sterility.

WASHINGTON COUNTY.

(E. A. S. & L. C. J.)

The northeastern corner of Washington county is occupied by the strata of the lower Tertiary or Eocene formation, including the *White Limestone*, *Claiborne*, *Burhstone*, and *Hatchetigbee* divisions. This variety is brought about by the circumstance that an anticlinal uplift of the strata



acteristic of it. This rock which exhibits many varieties furnishes the material for the chimneys and pillars of houses in all the region of its occurrence in this and adjoining states. The rock does not make its appearance at the surface except where the uplands break off towards the watercourses, for the reason that it is elsewhere covered by considerable depth of sands and other materials of the Lafayette.

The belt of lime hills extends from the northwestern corner of the county by Old Washington C. H., Koenton, and St. Stephens to the river and beyond, the road from Milry to St. Stephens following about along its lower or southern border. The belt is some four or five miles across, and includes some of the best farming lands of the county. Its characteristic soils are, (1) a loose black loam called "shell prairie" soil, timbered with dogwood, black and white oaks, sweet gum, ash, short leaf pine and buckeye. This is a soil very easy of tillage and very fertile, but unfortunately not very abundant. At the other extreme is (2) a stiff calcareous clay, black when mixed with vegetable matter, fertile but not so easy of cultivation. Intermixtures of this residual clay with the red loams of the overlying Lafayette give (3) stiff yellowish or mahogany colored soils in most respects similar to the post oak prairie soils of the regions further north; it is very productive but somewhat difficult of cultivation. Throughout this which we may call the lime hills or prairie belt, we find many interruptions of the characteristic soils of the formation; for in places the sandy pine lands extend almost entirely across the belt especially along the high divides where the Lafayette which is the producer of the sandy soils has been least effected by erosion. On the other hand long narrow strips of prairie lands extend for miles out into the piny woods along some of the streams, and everywhere the prairie or calcareous soils are interspersed with the sandy soils derived from the Lafayette mantle which has at one time covered the entire face of the county. The Lafayette therefore furnishes by far the greater part of the present soils of Washington, and among

crosses that part of the county in a northwest southeast direction bringing the Hatchetigbee clays to the surface along the central line of the uplift. This passes directly through Bladen Springs which have their source in these strata. From this uplift the lower Tertiary beds dip away towards the southwest, the Hatchetigbee clays being in the extreme northeast corner of the county and exhibiting a good face at the bluff of that name on the Tombigbee River. Next, towards the southwest, follows an outcrop of the Buhrstone which makes the rocky pine clad hills "chalk hills" about Rescueville and southeastward. The Claiborne proper does not show much on the surface except where its calcareous strata are mingled with the red loams of the pine hills when we have the so-called "piny woods prairies." A good outcrop of the Claiborne shell marl occurs along the Bladen Springs and St. Stephens road in section 29, T. 8 N. R. 2 W. The country under which this division of the Claiborne is found may be described as pine uplands with oak and hickory, very fair lands and in striking contrast to the rather poor pine hills of the Buhrstone. Both of these divisions occupy strips two or three miles across. Next follows the territory of the St. Stephens limestone. Where this rock underlies, its influence is generally to be seen upon the surface, either in the presence of lime sinks or in the calcareous soils. The lower part of the St. Stephens and consequently that part which comes to the surface furthest north, is a clayey limestone which in disintegrating yields a stiff calcareous clay soil very similar to that of the Cane Brake prairies further northwards. Where these strata lie nearly flat, they give rise to level prairies, especially where not much cut up by erosion, but where erosion has been more active they form the "lime hills" of this section, steep bluffy hills with stiff calcareous clay soils. exceedingly fertile but generally badly cut up by washes. The upper layers of the St. Stephens are made by what has been called the orbitoidal limestone from the presence of a flat-coin shaped shell the *Orbitoides Mantelli* which is char-

acteristic of it. This rock which exhibits many varieties furnishes the material for the chimneys and pillars of houses in all the region of its occurrence in this and adjoining states. The rock does not make its appearance at the surface except where the uplands break off towards the watercourses, for the reason that it is elsewhere covered by considerable depth of sands and other materials of the Lafayette.

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Section of new well dug one-fourth of a mile west of the spring (Healing Springs) at the school house in charge of Dr. Hammerlin and furnished by him with the specimens exhibited as saved.

1. Gray sandy soil and sub-soil of the hill ..... 3 feet.
2. Mottled sandy clay, possibly Lafayette, but rather too compact for that..... 12 feet.
3. Yellow sands with ochre and clay resembling many beds of Lafayette..... 10 feet.
4. Blue clayey sands, like many sections of Grand Gulf, with mud at base..... 12 to 15 feet.
5. Hard, firm quartzitic looking sand, whitish or gray..8 to 10 feet.
6. Looser sands, whitish, with water, only penetrated..... 8 feet

Water of taste decidedly mineral, like other Grand Gulf wells, but not by any means as strong as at the "Big Spring" on the creek, which is 50 to 100 feet lower.

There are other outcrops in this county of Grand Gulf rocks. One of these to be mentioned is at the head of Little Basset Creek, section 21 or 22, towship 7 or 6, range 2 west. In this vicinity is also a strong Chalybeate spring at Mr. John Richardson's, the pioneer and patriarch of the region. This is Sec. 33, T. 6, N., R. 2, W. Another bed of the sandy argillaceous rock is on Bilbo's Creek farther south and east, where there has been considerable erosion.

On the banks of these creeks in the vicinity of the crossings of the St. Stephens road from Mobile, the only exposures showed the stratified gray clays, resembling the Hattiesburg phase of the Grand Gulf formation, or more nearly the Pascagoula, but without fossils. The only other outcrop observed of this stone, and the only one in the region of the west drainage, is on the extreme edge of the county on the road between Escatawpa Station and State line, and ten miles south of the latter. This is the very backbone of the ridge between Escatawpa River and Chickasawhay. The very top is Lafayette deep and white, the quarry of the rock being located in washes below the summit. At a church on the road the material, it is scarcely stone, has been used for underpinning and enclosures for graves.

The *soils* of lower Washington, as might be expected from such geological constituents and structure, are remarkably thin. Even where they lie well, as on the elevated plains, they are too sandy or too wet on account of the tough clay, or are deficient in some principle necessary to render agriculture profitable. This is the general condition. Yet there are many spots of fertile land, and it is considered that all the "Second Bottoms," both of Tombigbee and the larger creeks are equal to similar lands anywhere in these southern counties. North of the mouth of Basset the Second Bottom bench, or terrace lands, are of higher grade. Perhaps there is more lime in the soil. It is not far from where the road from St. Stephens to Jackson strikes the bench lands, on the escarpments next the river that Vicksburg Orbitoidal limestone is quarried for chimneys.

Towards the western portion of the county there are many clearings on the head waters of Escatawpa River. The lands generally lie well, and though sandy seem to produce remunerative crops. However there can be no just appreciation of the agricultural capabilities of a county, where all the skill and energy of the people are invested in the primitive forest. The principal business of the county is to destroy the forest. Every creek and branch that at high water can float a log is utilized for "logging;" and where the timber is too far from the water, or from a railroad, the people engage in "turpentining." (The destruction must go on,) The waste from "boxing" is greater than from "logging;" for in getting out timber for the mills the small trees are spared and may benefit another generation; but in the process for obtaining the turpentine trees of all sizes are attacked; all die together, all get burnt up together. There is one spot not to be omitted from mention of the soils of Washington, which has no exact counterpart, so far as known, in the state. It would be a geological curiosity were it not for the fact that in Mississippi, within the Grand Gulf terraces,

there are a few like it. This prevents its being called strange, but does not help much to explain the phenomenon. On the state line and St. Stephens road above the head of Little Basset Creek in sections 21 and 22, as supposed, of T. 6, N. of R. 2 W., are several hundred acres of rich broken oak and hickory lands, locally known as "lime hills." Lime is conspicuously absent from them in any ostensible form. But the people also call the big rocks of sandy clay already mentioned above, which lie east immediately upon the border of this tract, lime rocks. These hills wherever not broken have in part been cleared, and are said to be very productive. This is the only approximation towards red soil known in the county south of Sinta Bogue. The counterparts of this tract, referred to in Mississippi, are 1st: One in Covington county and Jones, on the road from Ellisville to Bethel, after crossing Leaf River bridge; 2d, another more considerable in Perry county, north of Augusta, on the waters of Talahala; 3d, there are others in Marion and other counties mentioned by Dr. Hilgard. He explains these occurrences by a supposition of some old freshwater ponds in which are probably left the remains of shell producing animals. It might be explicable upon another hypothesis, namely, that set up in this report, that in both the upper Grand Gulf and the Pascagoula formations, there are traces of marine genesis, or of there having existed on this part of the Gulf coast at the period of deposition of these sandy clays by the Mississippi River, extensive shallow bays or lagoons, in which the great fresh water streams buried the shells of the salt water animals, together with the leaves and logs contributed by the streams from the land. And where now this phase of the formation comes to the surface or by lap-over crops out, there may be considerable calcareous matter and abundance of clay by the disintegration of which red soils are produced.

BALDWIN COUNTY.

(L. C. J.)

Baldwin County from north to south is not quite as large as Mobile and Washington Counties together, but is the longest in the state. It is one of the richest in timber, but otherwise considered one of the poorest. The population is scattered and except near the Bay, are engaged in "turpentining" and "logging." Comparatively a small portion stick to the primitive business of the piny woods, cattle raising, and a still smaller numbers are turning attention to a later but promising enterprise of "truck farming." At the extreme south there still flourishes the old trade of preying upon the inhabitants of the water, fishing on a small scale. It may be seen then that Baldwin is to the left of the embayment, precisely what Washington and Mobile Counties are to the right. Geologically, too, the structure is identical. The long sand beach from Ft. Morgan to Perdido Bay is not considered an island only because an arm of the sea does not separate it from the mainland.

But by means of small creeks running into Perdido on the one side and into Bon Secours Bayou on the other, small boats can pass from bay to bay; and in structure and soil this semi-island is the counterpart of Dauphin Island. The strip of low land between the coast sands and the hills to the north is not so wide as the corresponding plain on Fowl River.

It is capable of perfect drainage and there is any amount of water from the hills, by beautiful clear steams which might be used for irrigation and for many other useful purposes. The high hills of Baldwin have already been mentioned in Part I, as phenomenal. The Lafayette formation here reaches its best development; this is near the ocean and the only place where it may be seen from shipboard on the high sea. Like all the rest ot the Lafayette soil, it is considered of value at present for the timber. On the Perdido side are great cattle ranges. Although the Bayou

Minette sub-embayment is of great interest, from its fine tributary creeks and bench lands, true "Second Bottom" on the Baldwin side may be considered as beginning on the Tensas. On this and on the Alabama River are the principal farming lands of the county. There is no reason to doubt that geologically these "Second bottoms" are exact counterparts of those on the west; and that the broad belt subject to overflow has underlying the same formation more or less degraded by more recent fluviatile erosion, and subsequently covered by the thin coat of Alluvium now visible.

The Palmetto Swamps.—One section of this region has the local name of Palmetto swamps or brakes. Not that it is strictly swampy, but that most of it is subject to overflow. No doubt if once reclaimed and protected the swamp soils would all be remunerative. Small experiments near the city prove as much. But the subject is introduced here for another purpose. This is the largest palmetto brake known to the writer outside of Florida. The prevailing species is that dwarf variety known as "Blue Palmetto." From an agricultural point of view and to the lovers of fine pine timber, there is nothing very inviting about the palmettos; but something else might be made of it. In Jacksonville, Fla., there is an establishment for the manufacture of vegetable bristles and hair out of the dwarf palmettos, and another establishment proposes to take the refuse, in fact the whole plant, and make from it the finest paper. Here then in this part of Baldwin we have palmettos and trees worthless for timber, all of which with our climate and our unrivaled supply of soft clear running water from the hills, could be turned into paper pulp of great commercial value. The soil would still be left of more value than before, which cannot be said of the beautiful region of the pines.

The Elevations.—The elevations in Baldwin have already been referred to. The highest points as in all this part of Alabama and Mississippi, are the Lafayette covered hills. The most elevated portions, a little southeast from Daphne, are said to be 400 feet. From the profile of the L. & N. R. R., the summit of the track near Bay Minette is 279

feet, and this being in a cut, and reasonably selected by the engineers as a low point, the ridge cannot be estimated at less than 400 feet. Even at the banks the crossing of Perdido River on this railroad, is 145 feet above tide water, and Perdido station is 234 feet. The more recent survey for the projected Memphis, Meridian and Pensacola R. R., which crosses about the line of the old Jackson military road in the northern part of the county, shows the elevations there to correspond pretty well with those in Washington county, being at the summit between Sand Creek and Red Creek, Washington county, 380 feet; and between waters flowing west and that flowing east into Sinta Bogue 303 feet, which corresponds with the crossing of the ridge southward of the head waters of Little River in Baldwin. It is connected with this survey to remark that the elevations given for the southern portions of both these counties, Baldwin and Washington, are something less than those ascertained for these great ridges farther south. The point has a geological bearing. It is precisely in these two regions, the northern parts of the counties, that the Lafayette formation thins out the most. This remark is properly due to the northeast portion of Baldwin where it corners with Escambia. The northwestern part of it immediately west of Tensas P. O., at the head of the Double Branches on Little River, is not only the highest land, but apparently the Lafayette is as deep as anywhere, and it is here graded by the most remarkable gravel beds, in this part of the state. The fact was no doubt marked by the engineers running the line of the new railroad. Should such a railroad ever be built, this deposit of gravel will be of great industrial importance. In all respects it resembles the gravels at Carter's Hill, Miss., on the I. C. R. R., and the Rosetta beds now of so much importance to the city of New Orleans on the L. N. O & T. R. R. in Amite County, Miss.

The Grand Gulf Formation.—Our knowledge of this group in Baldwin must be derived from the fewest possible

exposures. Were it not for the grand revelations of it in Mississippi and the very decided outcrop in Washington county, all that this county has to show might be overlooked or described as something else; might be taken for an uncommon sort of gray clay of the Lafayette. There is, however, in all the minor streams emptying into the Tensas above Stockton P. O., and especially in the streams that flow into Alabama bottoms, a deep gray laminated or stratified clay closely resembling, the Hattiesburg form of the Grand Gulf clay, and thin and small as the exposures are, they can receive no other interpretation. The most northern of these is the best so far as seen, already mentioned as occurring on the Mt. Pleasant and Tensas road, at what is called the Double Branches. The hill on the south side of the crossing may be 50 or 60 feet high, and except a thin layer 10 to 15 feet of Lafayette on the top, consists of such clay. The exposures are made by deep washes in the old, often changed wagon road. Some land sliding has caused an unusual uniformity in its appearance, and further division of the section was not possible.

Northward of this no bluff or exposure that could be regarded as decisive could be heard of on Little River. But in the next county to be mentioned again, on Shomo's Creek, occur the same clays under Lafayette. To the east are the most abundant exposures now referred to this formation, the true character of which, but for the similar manifestations in Washington county and in Mississippi, would not have been suspected. These are flats, whence takes rise the Perdido River. It is of the most uninviting appearance. The old Jackson trace passes over a region for twenty or thirty miles without a sign of human habitation.

Going eastward the sand thins out, soon there is not enough of it to supply a spring, and running streams disappear. The beds of old torrents are dry; the hills have only pines and not the best; and the soil where the sand has been washed off, is a soft stiff gray greenish, and in places pinkish clay. Very little equal to this was described in Washington county. In Jones county, Mississippi, unfor-

tunately for it, such tracts of the Grand Gulf clay are pretty well developed on Tallahala and between it and Bogue Homa. Not knowing the county lines in the uninhabited region above described, there is no telling how much of it belongs to Baldwin and how much to Escambia.

MOBILE COUNTY.

(E. A. S. AND L. C. J.)

The central part of Mobile county is occupied by the Maubila ridge the water shed between the Mobile and Escatawpa rivers. This ridge with constantly diminishing altitude extends down to within two or three miles of the Gulf. At Citronelle in the railroad cut the elevation is 333 feet while hills in the vicinity rise 30 feet higher, at the first summit on line of the survey of the Mobile and Jackson R. R. it is 257 feet. At Spring Hill it is 215 feet and at St. Elmo Station on the L. & N. R. R. it is 130 feet in a cut 30 feet deep, equal to 160 feet. The width of this ridge varies as the head waters of the several branches of the two drainage systems approach to or recede from the central line of the divide, being sometimes as Prof. Stelle describes it a mere back bone sometimes a plateau a mile or two in width. From this dividing ridge there is a gentle descent to the broad second bottoms of the Mobile on the one side and of the Escatawpa on the other. Further to the south the lowlands becomes marshes and pine meadows, the latter occupying the narrow strip on the southwestern border of the county which is an extension in this direction of the Pine Meadows of Mississippi and Louisiana underlaid by the older part of the Biloxi or Port Hudson formation.

The geological substratum of this county is made by the upper measures of the *Grand Gulf* and by the *Pascagoula* clay sands, neither of which however, impresses itself very forcibly, except that the impervious clay sands of the Grand Gulf are apt to give rise to badly drained depressions which are filled with water in the wet seasons and become ponds or lakes.

Below the Grand Gulf beds lie the strata of the *White Limestone* of the Eocene or lower Tertiary, and it is quite possible that some of the depressions above mentioned may have been initiated in this limestone formation, though generally it lies too far below the surface to have any widely felt influence upon the topography. The greater part of the surface of the uplands is occupied by the materials of the Lafayette, sands and gravel, and clays, and the Grand Gulf and Pascagoula beds mentioned come to the light only along slopes or where the Lafayette has been partially or wholly removed by erosion. No definitely determined outcrops of the Grand Gulf have been recorded in Mobile county, though the high badly drained flats of the upper part of the county undoubtedly owe their existence to the impervious sandy clays of this or the Pascagoula formation, and the laminated clays seen along some of the lower courses of the streams flowing into the Mobile river, can be assigned to one or the other of these.

Along the Mobile river we discover two well marked terraces above the first or overflowed bottom. The upper of these which we have usually called the *Third terrace* lies some 50 to 75 feet above high water, it is a mile or more in width, and its surface materials are not to be distinguished from those of the divides, viz., of the Lafayette.

The *Second Bottom* or terrace which lies always a few feet only above high water mark is less wide and has for surface material a yellow loam which is every where a good soil former and a good brick clay. Upon this second bottom are located all the great river plantations. We need not repeat here the characters of this formation which have been given somewhat in detail above in the general part of this report. Contemporaneous with this Second Bottom is the terrace upon which the city of Mobile stands, covered in many places by sands recently washed down upon it from the adjacent hills. Below the surface at depths of 15 to 18 feet there are found commonly in digging wells, remains of vegetable matters in the shape of logs, sticks, and stumps in various state of preservation. These gener-

ally impair the quality of the water. The Mobile terrace passes gradually into the Mon Louis terrace which has an underlying stratum with oyster and other estuarine shells. Along the coasts these flats extend around to the Mississippi line and there the geological formation has been called the *Biloxi*, which is only the Gulf coast equivalent of the Mon Louis Island and Mobile terrace and of the Second Bottoms or second terraces of the rivers, and of the Port Hudson of Mississippi.

This formation was once considered a member of the Tertiary and was spoken of as the Coast Pliocene, but the recent investigations have assigned it to its proper position which is Pleistocene or Post Tertiary. In appearance the Lafayette overlies it, but this is due to the fact that it has been deposited along the margin of Lafayette terraces which have been lowered by erosion, so that the later coast and river formations have been laid down over them. The character of the fossils included in this late formation varies with the locality. Along the coast we have *oyster* shells, higher up the streams the *gnathodon* which is a brackish water shell, and along with both the vegetable remains which are so characteristic. The shells are found as high up as the mouth of the Mobile river, and perhaps even further which would lead us to conclude that at the time these deposits, or at least a part of them, were accumulated, the land was relatively lower than it is now and there was free communication between Mobile Bay and the waters of the Gulf. To the upper measures of this Biloxi formation must be referred the soils of the bordering islands as well as of the narrow strip between the Lafayette ridge and the Gulf, in places not more than a mile in width. This soil though sandy and meagre is capable of drainage and is hopeful and in many places suitable for truck farming. The Pine Meadows in Alabama occupy only a narrow strip in the southwestern part of the county. They extend slightly up small tributaries of the Escatawpa, but have been so covered and tempered with sands washed from the hills, as not to be credited on account of surface appearances to the full extent of actual

development. Little more need be said of this tract; generally it is wholly unfit for agricultural purposes. In the sandy places there is some fine timber, more strictly it should be said there *was* timber, for most of it like the rest of our wonderful forest has been destroyed or largely thinned. In the very lowest parts there is also (or was) some valuable cypress timber. Very little of this however, will fall on the Alabama side of the line.

Springs and streams.—The structure of this county can not be understood without regard to its fresh water streams. As with all Lafayette regions there is no lack of good water here, this county is uncommonly well supplied. Wells are easily obtained anywhere on the main ridge, though the depth is often considerable, to the ordinary pure soft water of the formation, identical with that which in the valleys flows out by springs. In the flats or Second bottoms, water is also abundantly obtained by piercing through the superficial layers to the underlying clays, but it is generally mineral and sometimes offensive, from decaying vegetable matter, common in this intermediate stratum.

The number of the small streams alluded to and their perennial flow of clear soft water, have long been observed and regarded by the people of the City and of the wealthier planting districts, in selecting locations for health resorts. Hence Citronelle, Beaver Meadow, and the Grand Bay stations. Spring Hill five miles west of the city is noted and is much visited for its pure air and pure water. Doubtless for this reason it was selected by the Jesuits for the location of one of their most renowned colleges at the South. One of the larger creeks in this vicinity has been secured for "Water Works" to supply Mobile with that which before was very much needed.

The water system of these hills is peculiar. Many of the streams are large enough to drive mills, and some of them were so utilized before the advent of steam. But most of them are small, of the class called "spring branches." They by their long erosion have now their heads near the middle of the ridge, and flow both east and west. Those flowing

eastward often large enough to be called rivers, empty directly into the Bay, or the main river system, without swamps, bays or flats, except south of Mobile about the Dog river estuary, and parts of the main Fowl river bayou. The streams flowing west into Escatawpa, towards the southern end of the county, first reach the Pine Meadow flats and often become swamps. There is among them another curious fact to note:—that both branches of Franklin creek or bayou rise within a mile of the Gulf and flow northward many miles to join Escatawpa River at its western bend,—the extreme southern end of the Orange sand or Lafayette ridge being more elevated than it is some miles to the northwest of that point.

The Soils—Depend more upon the drainage, and the superficial changes effected by meteorological waters than upon deep underlying geological structure. But as this is the basis it cannot be overlooked. Consequently upon the high sandy ridge the soil is thin, because though the drainage is perfect, and rains sufficient, the material is wanting. Yet there are many table lands of the summit, having a red loamy soil upon which once flourished farms of cotton and corn. These lands are well adapted for fruit culture, and only need an application of "brains" with suitable fertilizers.

Farther toward the south, though the table lands narrow, the more deep and fertile are the red loams. The red lands about St. Elmo and Fernland and Grand Bay, are still productive with the use of proper fertilizers.

The "Second Bottoms" on the Tombigbee side are naturally of a more generous nature. The original growth was more varied. Large plantations were once profitable here, and many are still continued. These lands are not naturally so fertile, however, as the same class are farther north in the Calcareous regions. The underlying geological formations consist of gray and greenish clays of the Grand Gulf Tertiary period, having but little lime in them, and only upon a few of the creeks to the north do they come to the surface sufficiently to affect the soil. The terrace lands are

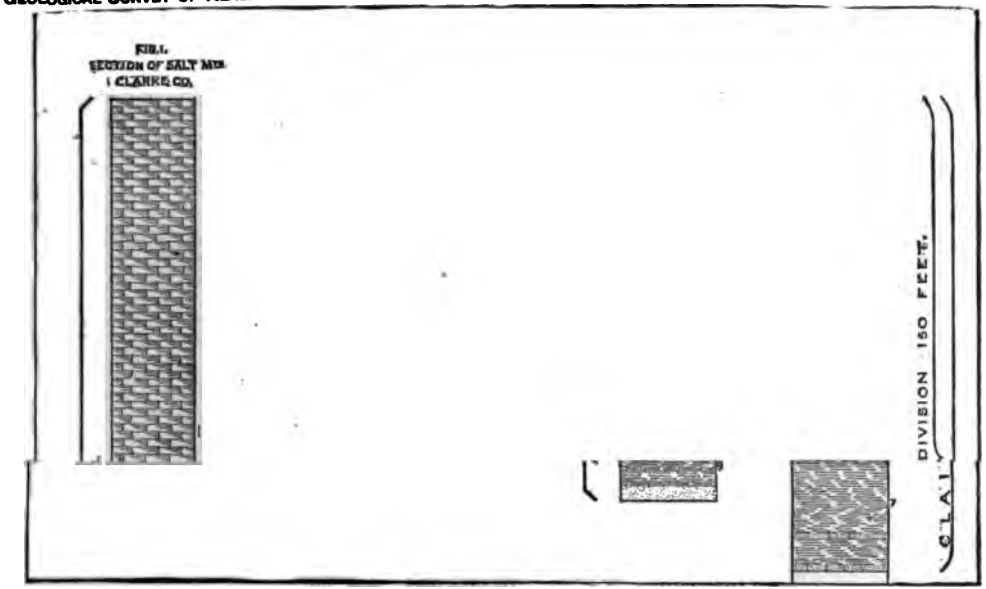
the most sandy of their class, for nowhere in them are the stiff tertiary clays exposed so as to be incorporated with the soil.

From Chickasa Bogue, northward, most of the streams cut through the Orange sand (Lafayette) and through Second Bottoms sufficiently to expose to view the older group, but it is only by snatches. The best exposure known to present writer is in the Railroad cuts at Chestang station. South of Whistler the boundary between the true "Second Bottoms" and the newer formation of the Coast sands, called the Biloxi is ill defined. The "Second Bottom" is thought to include the city of Mobile, and to extend below it probably to Fowl River, but next to the hills: whilst Mon Louis Island, and the Bay front perhaps to Choctaw point is of the Biloxi, or the Marine equivalent of the Second Terrace.

Useful materials.—The useful materials of the geological formations of Mobile county are derived chiefly from the Lafayette formation, and they are pebbles for ballast and for road making; sands for various purposes; clays for brick and tiles and other wares, though the best quality of brick clay is associated with the Second Bottom deposits; ochres yellow and red; coarse building stone in the form of the ferruginous sandstones and iron crusts which are found wherever a bed of some kind of impervious material as clay underlies a stratum of red sand or loam. Some of the rocks of this character are quite rich in iron and might pass for lean ores of iron, yet they all contain too much silica to be profitably used.

PLATES XIX--XXIX.

WITH EXPLANATIONS.



Scale: 1 inch = 40 feet.

SECTIONS OF THE WHITE LIMESTONE ON ALABAMA AND TOMBIGBEE RIVERS.

PLATE XIX.

SECTION OF THE WHITE LIMESTONE ALONG THE TOMBIGBEE AND ALABAMA RIVERS, IN PART SHOWING THE RELATIVE POSITIONS OF THE WHITE LIMESTONE AND THE CLAIBORNE BEDS.

FIG. 1. *Section of Salt Mountain, Clarke County.*

1. White Limestone, Salt Mountain. This limestone consists in great measure of masses of partially silicified corals. In the lower strata compact, crystalline limestone occurs, which holds plates and spines of echinoderms.....150 feet
2. Orbitoidal White Limestone quarried for building purposes.20 feet

FIG. 2. *Saint Stephens Bluff, Tombigbee River.*

1. Soft White Limestone, with *Orbitoides Mantelli*. The upper half contains this fossil in great abundance, the lower part more sparingly. The lithological character of the whole 70 feet is quite uniform. The top of Saint Stephens Bluff is here represented as equivalent to the top of the orbitoidal limestone at Salt Mountain, giving the *minimum* thickness of this rock. There may be, a greater thickness of this rock than here shown.....70 feet
2. Indurated bed of *Spondylus dumosus*.....3 feet
3. Light yellowish white marl or argillaceous limestone, containing nodules of phosphate of lime. The marl itself is strongly phosphatic.....27 feet

FIG. 3. *Section at Baker's Hill, continuation of Saint Stephens Bluff, showing relative position of the White Limestone and the Claiborne sands, Tombigbee River.*

1. Orbitoidal White Limestone forming summit of hill, passing into the argillaceous limestone below (line between the two here rather arbitrarily drawn).....25 feet
2. Argillaceous, glauconitic limestone, with *Pecten perplanus*, *Pecten Poulsoni*, &c. This is the same rock as that at base of Saint Stephens Bluff, half a mile distant and in plain sight. The strata are covered at intervals by debris.....55 feet
3. Bed with *Scutella Lyelli*, 1 foot seen, at other points.....8 feet
4. Coarse, ferruginous sands passing downwards to reddish sand, holding the usual Claiborne fossils of unmistakable character.....15 to 18 feet
5. Bluish green, glauconitic, and clayey sands, containing the *Flabellum* found at Coffeeville.....8 to 10 feet

FIG. 4. *Strata exposed in continuous bluffs between Marshall's Landing and Rattlesnake Bluff, just below Claiborne, showing relative positions of the White Limestone and the Claiborne sands, Alabama River.*

1. Orbitoidal White Limestone of usual character .....10 feet
2. White Limestone, containing great numbers of *Scutella Lyelli* and other echinoderms.....10 feet
3. Calcareous clay in two beds of five feet each, separated by three feet of soft, earthy White Limestone. Below this, a ledge of hard limestone three feet and eight feet of blue clay with fucoids, becoming more calcareous below, in all .....about 24 feet
4. Ledge of hard, white limestone, followed by twenty feet or more of argillaceous, soft, white limestone, with thin projecting ledges of purer limestone at intervals. Resembles the Rotten Limestone of Cretaceous formation... .....about 25 feet
5. Bed of *Scutella Lyelli*, in three layers, the middle one ferruginous.....3 feet
6. Coarse, ferruginous sand, calcareous below, hard ledge at bottom .....6 feet
7. Claiborne ferruginous, fossiliferous sands, the counterpart of those at Claiborne Bluff.....10 to 12 feet
8. Calcareous, sandy clay, with hard ledge in middle.....6 feet
9. Sandy, clay marl, with *Ostrea sellæformis*; four or five hard ledges passing into greensand below.....12 feet

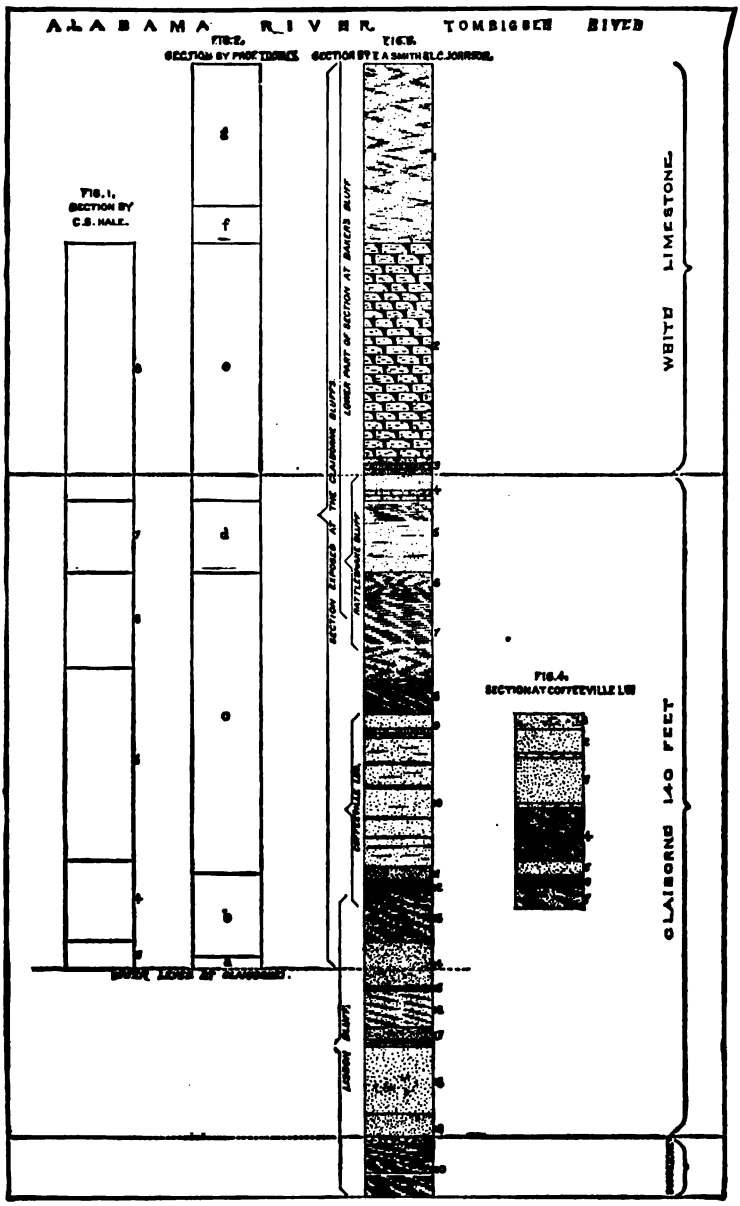
FIG. 5. *Section of upper part of bluff at Claiborne and part of hill back of bluff, along the road to Perdue Hill, Alabama River.*

Hill back of river bluff.

1. White Limestone filled with *Orbitoides Mantelli*, occurring on road to Perdue Hill, 100 feet or more above top of bluff at Claiborne Landing. Tertiary strata covered by Lafayette along road leading from Perdue Hill up to Claiborne..... .....90 to 100 feet
   Tertiary strata covered by Lafayette, at top of river bluff..... .....38 to 40 feet

Upper part of bluff

2. White or light colored, argillaceous limestone with glauconite grains.....45 feet
3. Indurated ledge of *Scutella Lyelli*..... 3 feet
4. Coarse, ferruginous sand, calcareous below, indurated at base.....6 feet
5. Claiborne fossiliferous sands, ferruginous. Lignitic in places above.....15 to 17 feet
6. Bluish green, glauconitic, sandy marl, with *Ostrea sellæformis*, part indurated .....4 feet


ALABAMA RIVER
TOMBIGBEE RIVER
FIG.1. SECTION BY C.S. HALE.
FIG.2. SECTION BY PROF. TUOMEY.
FIG.3. SECTION BY E.A. SMITH & L.C. JOHNSON.
FIG.4. SECTION AT COFFEEVILLE L'ING
SECTION EXPOSED AT THE CLAIBORNE BLUFFS.
LOWER PART OF SECTION AT BAKERS BLUFF
RATTLESNAKE BLUFF
COFFEEVILLE L'ING
LOWER BLUFF
WHITE LIMESTONE.
CLAIBORNE 140 FEET
Scale: 1 inch = 40 feet.

SECTIONS OF THE CLAIBORNE STRATA, ALABAMA AND TOMBIGBEE RIVERS.

7. Calcareous, bluish gray clay, few badly preserved fossils, passing below into a greenish, glauconitic marl containing great numbers of young *Ostrea sellæformis* and a few *Pectens*, together about 18 feet; below this, light gray, calcareous clay, similar to top of preceding hard, sandy ledge at top and bottom, 7 feet; in all.....25 feet

PLATE XX.

ILLUSTRATING THE CLAIBORNE STRATA AS EXPOSED ALONG THE ALABAMA AND TOMBIGBEE RIVERS.

FIG. 1. *Section by C. S. Hale.*

No 8. White Limestone, thickness not given by Hale.
No. 7. Yellow, quartzose sand, highly fossiliferous; seam of earthy lignite near the middle.....15 feet
No. 6. Clay with shells of full grown *Ostrea sellæformis*.....20 feet
No. 5. Marly, arenaceous beds, with same shells as are common in the other beds; thickness not given by Hale.
No. 4. Argillaceous, muddy deposits. Fossils mostly oysters, except *Venericardia planicosta*, *Arca*, and *Turritella;* occurs also at Coffeeville.....15 to 20 feet
No. 3. Only a few feet at Claiborne; greensand running gradually into No. 4.

FIG. 2. *Section by Professor Tuomey.*

g. Red loam, sand, and pebbles.....30 feet
f. White and mottled clay..... 8 feet
e. Limestone, with a small percentage of greensand.....54 feet
d. Sandy, fossiliferous beds.....15 feet
c. Whitish limestone, with bed on top containing *Ostrea sellæformis* and *Scutella Lyelli*. This bed passes below into a bluish marl with shells.....62 feet
b. Bed of clay, with limestone seam on top. This bed is more calcareous below and contains fossils that, as a group, are peculiar.....15 to 18 feet

FIG. 3. *Section by E. A. Smith and L. C. Johnson.*

1. Red loam, sand, and pebbles.....35 to 40 feet
2. Argillaceous limestone, with greenish grains.....45 feet
3. Indurated ledge, with *Scutella Lyelli*.....3 feet
4. Coarse, ferruginous sand, calcareous below; indurated ledge at base.....6 feet
5. Claiborne fossiliferous sands; ferruginous, with shells; lami-

nated lignitic clays, with leaf impressions, and thin seams of lignite in places in upper part.....15 to 17 feet

6. Bluish green, glauconitic sandy marl, containing *Ostrea sellæformis*, in part indurated.....3 to 4 feet
7. Calcareous, bluish gray clay, with a few badly preserved fossils, passing downward into a greenish, glauconitic sandy marl, containing great numbers of young shells of *Ostrea sellæformis* and a few *Pectens*, the two together, clay and sand....about 18 feet
8. Light gray, calcareous clay, similar to the preceding, with hard, sandy ledges at top and bottom, in all.....about 7 feet
9. Light yellowish gray, calcareous sands, with *Pectens* and *Ostrea sellæformis*, the lower half indurated, containing casts of univalve shells.....about 5 feet
10. Light yellowish gray, calcareous sands, with thin beds of more clayey texture and with five or six hard, sandy ledges at intervals; the sand is, in places, loose and crumbling, and quite fossiliferous, with *Ostrea sellæformis*, *Pecten Deshayesii*, fragments of *Scutella Lyelli*, &c., lower 8 feet a bluish, clayey sand.....about 27 feet
11. Bed of greensand, with perfect shells and fragments of *Ostrea sellæformis*, &c.....about 3 feet
12. Dark blue, nearly black, sandy clay.....2 feet
13. Bluish green, clayey sands, few fossils above, but highly fossiliferous below and rather more clayey, *Venericardia planicosta*. *Nucula magnifica*, *Ostrea sellæformis*, *Arca rhomboidella*,, *Voluta Sayana*, *Turritella Mortoni*, *T. bellifera*, &c.....10 feet
14. Dark grayish blue greensand, peculiar small form of *Venericardia planicosta*, large *Turritella Mortoni*, &c., 6 feet at Claiborne, but 10 feet in Lisbon.
15. Hard, sandy ledge .....8 inches
16. Calcareous, clayey sands, light yellowish to white color..8 feet
17. Coarse, ferruginous sands, with numerous fossils.....8 feet
18. Light yellow sand, capped with a hard ledge, forming perpendicular bluff.....15 feet
19. Blue, glauconitic sands, probably a modification of 18.....5 feet
20. Bluish black clay; top of Buhrstone contains curious concretions of sandy clay, like interlacing roots.

FIG. 4. *Section at Coffeeville Landing, Tombigbee River.*

1. Light yellowish sands, partly indurated, with *Ostrea sellæformis*, &c.....3 feet
2. Loose, yellowish, calcareous sands, with *Ostrea sellæformis*. Indurated sand ledge at base.....6 feet
3. Loose, yellowish gray, calcareous sands, highly fossiliferous below, *Ostrea sellæformis*, the chief form, separated from next by

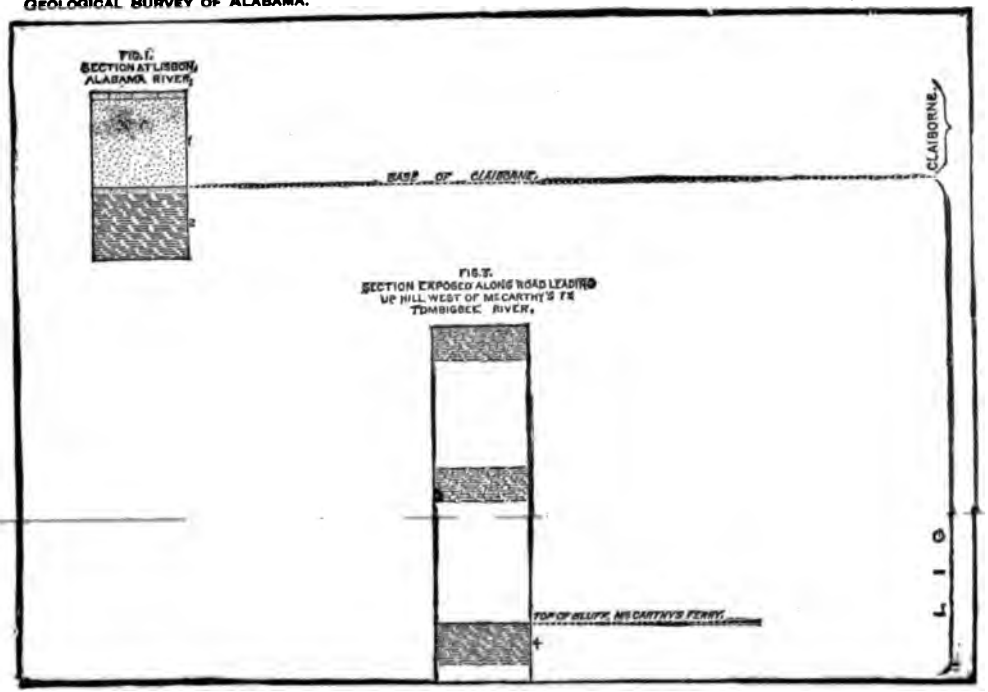


FIG. 1.
SECTION AT LISBON, ALABAMA RIVER.
BASE OF CLAIBORNE.
CLAIBORNE.
FIG. 2.
SECTION EXPOSED ALONG ROAD LEADING UP HILL WEST OF MCCARTHY'S FY TOMBIGBEE RIVER.
TOP OF BLUFF, MCCARTHY'S FERRY.
L I O

Scale: 1 inch = 40 feet.

hard, sandy ledge.....10 feet
4. Bluish, clayey sand, with *Ostrea sellæformis* and *Flabellum*, in two parts, separated by hard ledge; upper part, 8 feet; lower, 3 feet in all.....12 feet
5. Glauconitic sands, filled with comminuted and perfect shells of *Ostrea sellæformis*, &c.....8 feet
6. Dark bluish black, non-fossiliferous, sandy clays.....2 feet
7. Dark bluish green, clayey sands to water level.....5 feet

PLATE XXI.

SECTIONS OF THE BUHRSTONE STRATA WITH THE ADJACENT STRATA OF THE CLAIBORNE AND LIGNITIC.

FIG. 1. *Section at Lisbon, Alabama River.*

1. Light yellow sands, with glauconite, capped with hard ledge, lower 5 feet of bluish color, base of Claiborne rocks.....20 feet
2. Bluish black jointed clay, sandy concretions in upper part, 15 feet

FIG. 2. *Section at Hamilton's Landing, Alabama River.*

1. Light gray, indurated clays and aluminous sandstones, with one or two ledges, forming the whole of the bluff at Hamilton's Landing.....75 feet

FIG. 3. *Section exposed along road leading up hill west of McCarthy's Ferry, Tombigbee River.*

1. Top of hill west of McCarthy's Ferry, in Choctaw county. On the road down to the ferry 250–270 feet of Buhrstone rocks are passed over. These consist of indurated clays, claystones, and aluminous sandstones; the relative positions and order of succession of the different beds not intended to be represented in figures. These rocks appear at the surface at short intervals all the way..... exposed 270 feet
2. Ledge of silicious sandstone or quartzite, interstratified with indurated clays.
3. Laminated clays, reddish and yellowish, just below Buhrstone rocks on road down the hill; strata exposed just back of bluff of river.
4. Sandy clays, &c. (Continuation, see Fig. 3, Plate XXII.)

FIG. 4. *Section of upper part of White Bluff, below Wood's Bluff, Tombigbee River.*

1. Aluminous sandstones and indurated clays with jointed structure, forming a clear, perpendicular Bluff.....115 feet
2. Grayish, sandy clays, with a layer 18 inches thick at base, containing lignitized stems and twigs.....20 feet

8. Sandy clays, lignitic layer at base.....5 feet

FIG. 5. *Section of the upper part of Hatchetigbee Bluff, Tombigbee River.*

1. Light colored, aluminous sandstone and indurated clays, 20 to 80 feet
2. Sandy clays, brown, yellow, and red, interstratified, bluish when wet, but lighter when dry .....20 feet
3. Heavy bedded, brownish clays, darker than the preceding, 10 feet

PLATE XXII.

ILLUSTRATING THE HATCHETIGBEE SECTION OF THE LIGNITIC, BUT INCLUDING ALSO A PORTION OF THE LOWER PART OF THE BUHRSTONE AND THE UPPER PART OF THE WOOD'S BLUFF SECTION.

FIG. 1. *Section of White Bluff, Davis's Bluff, and Wood's Bluff, Tombigbee River.*

1. Buhrstone rocks, chiefly aluminous sandstones and indurated clays, with jointed structure and prevailing light gray colors, forming a perpendicular cliff .....115 feet
2. Grayish, sandy clays, with a layer 18 inches thick at base, containing lignitic stems and twigs .....20 feet
3. Sandy clays, with lignitic layer at base.....5 feet
4. Strata obscured by landslides.....65 feet
5. Dark gray, sandy clays, striped with brownish purple bands of clay containing very few fossils, except in a thin band of marl 12 feet above the water and one 24 feet above the water, all exposed in Davis's Bluff.....70 feet
6. Dark gray to brown, sandy clays, between Wood's Bluff and Davis's Bluff .....10 feet
7. Bluish, sandy, fossiliferous clay, red on surface, hard ledge at top.....3 feet
8. Bluish, clay, like No. 7, but not fossiliferous, passing into greensand below.....7 feet
9. Fossiliferous, clayey greensand.....3 feet
10. Greensand marl, with stratum of ponderous oyster shells, highly fossiliferous; tends to form rounded bowlders .....10 feet
11. Fossiliferous greensand, loose and easily washed out, forming caves under the bowlders.....8 feet
12. Thin band of lignite over greenish, non-fossiliferous, clayey sands .....5 feet
13. Laminated, gray, sandy clays.....3 to 4 feet
14. Lignite.....8 feet or more

FIG. 2. *Section at Hatchetiqbee Bluff, Tombigbee River.*

1. Drift and surface materials, light colored, aluminous sandstones and indurated clays, Buhrstone rocks.....20 to 30 feet
2. Sandy clays of brown, yellow, and red colors, interstratified, blue when moist, lighter color when dry .....15 to 20 feet
3. Heavy bedded, brownish clays of darker color than No. 2, 10 feet
4. Yellowish, glauconitic marl.....3 feet
5. Purplish brown, sandy clays, with band of hard, dark colored clays in middle, projecting.....15 feet
6. Yellowish gray sands, striped with brown clays, forming bowlders at intervals.....6 feet
7. Blue clay marl, sandy, many new forms.....5 feet
8. Grayish sands striped with clay bands, bowlders.....4 feet
9. Heavy bedded, gray, sandy clays, with brown clay stripes, indurated at base.....8 feet
10. Reddish, fossiliferous sand, *Venericardia planicosta* abundant, 5 feet
11. Dark gray to brown, sandy clays, to water's edge.....15 feet

FIG. 3. *Section at McCarthy's Ferry, Tombigbee River.*

1. Buhrstone rocks exposed along road leading up the hill from McCarthy's Ferry. See Fig. 3, Pl. XXI.
2. Laminated clays, reddish and yellowish, containing an indurated greensand marl with Hatchetigbee fossils, exposed in hill above the bluff and intervening between the strata seen in the river bluff and the aluminous rocks of the Buhrstone seen higher up the hill.....about 75 feet
3. Sandy clays interstratified with clays less sandy, light gray, along the whole length of the bluff. There are parallel bands of much darker brown clays.....55 feet
4. Laminated clays and sands, firm and compact at base, and forming projecting ledge.....5 feet
5. Pyritous sandy clays, with two or three bands of darker color, indurated in places, forming bowlders.....20 feet

PLATE XXIII.

ILLUSTRATING THE WOOD'S BLUFF OR BASHI AND BELL'S LANDING SECTIONS OF THE LIGNITIC, AND INCLUDING THE LOWER BEDS OF THE HATCHETIGBEE SECTION.

FIG 1. *Section at Yellow Bluff, Alabama River.*

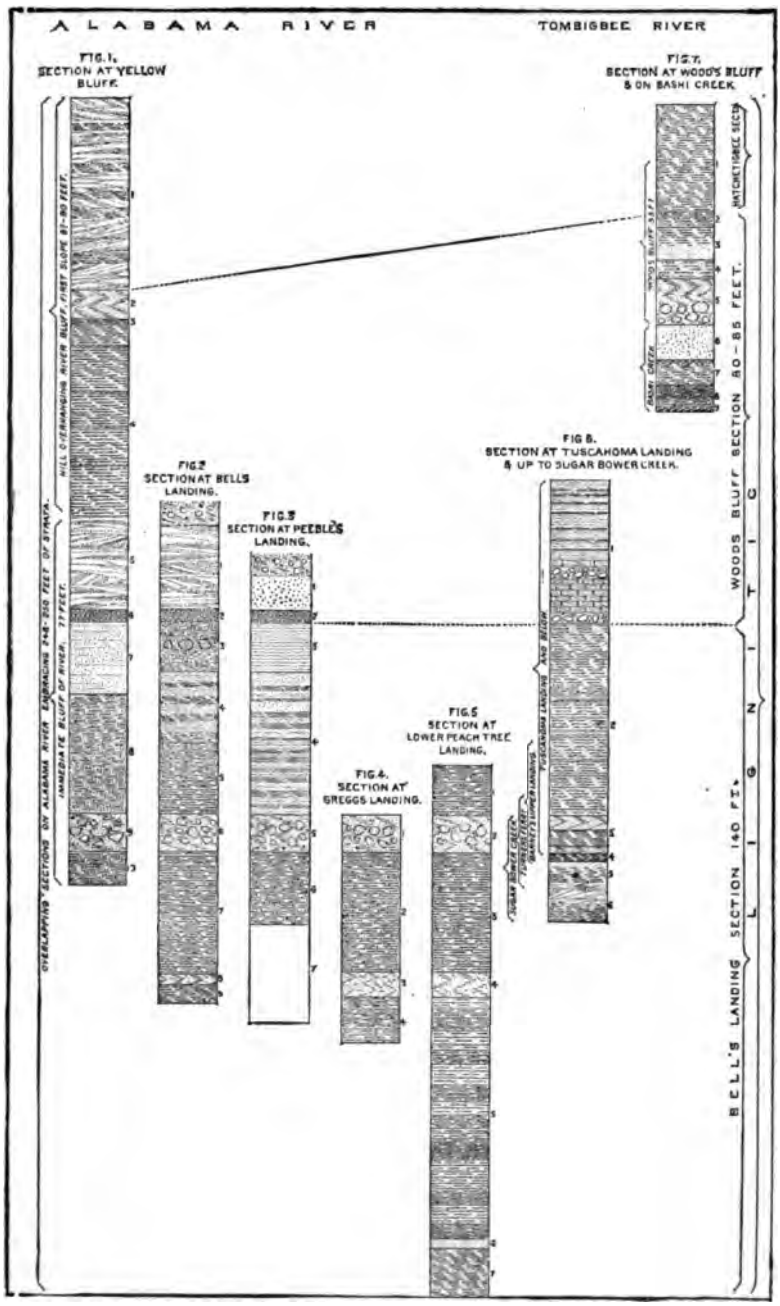
1. Gray, sandy clays, with cross-bedded sands. Forty feet seen in one exposnre in river bank and 90 feet more seen on the hills within 1 mile of the river. Only the lower 40 feet occurring at river are here shown.....40 feet
2. Greensand marl, Wood's Bluff fossils.....6 feet or more
3. Blue clay.....1 foot
4. Gray, sandy clays of slightly purple tinge, containing four or five thin seams of lignite.....40 feet
5. Reddish, cross-bedded sand.....20 feet
6. Lignitic clay and lignite..... 2 feet
7. Reddish sands, slightly laminated.....15 feet
8. Gray, sandy clays, laminated, forming perpendicular cliff..25 feet
9. Greensand marl, indurating into bowlders, Bell's Landing fossils..... 8 feet
10. Greenish, ferruginous sands interlaminated with thin sheets of clay to water level..... 7 feet

FIG. 2. *Section at Bell's Landing, Alabama River.*

1. Yellowish, cross-bedded sands.....15 feet
2. Lignite.....2 feet
3. Laminated, sandy clays, with a few large, bowlder like concretions.....10 feet
4. Yellow, stratified sands, alternating with gray, sandy clays.15 feet
5. Gray, sandy clays, laminated.....15 feet
6. Greensand marl, forming bowlders, gigantic shells...6 to 10 feet
7. Dark gray, laminated, sandy clay.....25 feet
8. Sandy, clay marl.....1 to 2 feet
9. Dark gray, sandy clay to water level.....3 feet

FIG. 3. *Section at Peebles's Landing, Alabama River.*

1. Yellowish sands.....1 to 2 feet
2. Lignite and lignitic clay.....2 feet
3. Reddish sands, laminated.....10 feet
4. Gray clays and sands, variously interstratified.....about 30 feet
5. Greensand marl, forming bowlders, Bell's Landing fossils..3 feet
6. Dark gray, sandy, laminated clays.....25 feet
7. Strata covered by second bottom deposits, down to water level.....20 feet


ALABAMA RIVER
TOMBIGBEE RIVER
FIG.1, SECTION AT YELLOW BLUFF.
FIG.7, SECTION AT WOOD'S BLUFF & ON BASHI CREEK.
FIG.2 SECTION AT BELLS LANDING.
FIG.3 SECTION AT PEEBLES LANDING.
FIG.4. SECTION AT GREGGS LANDING.
FIG.5 SECTION AT LOWER PEACH TREE LANDING.
FIG.6. SECTION AT TUSCAHOMA LANDING & UP TO SUGAR BOWER CREEK.
WOODS BLUFF SECTION 80-85 FEET.
BELL'S LANDING SECTION 140 FT.
LIGNITIC

Scale: 1 inch = 40 feet.

WOOD'S BLUFF OR BASHI SECTION AND BELL'S LANDING SECTION OF THE LIGNITIC.

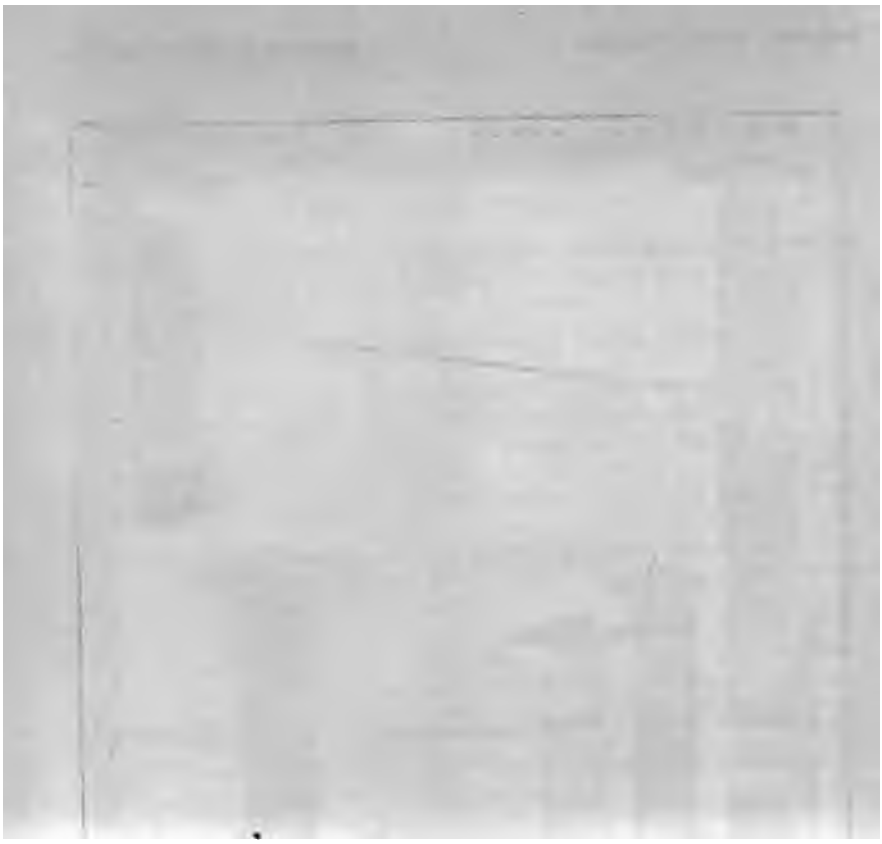


FIG. 4. *Section at Gregg's Landing, Alabama River.*

1. Greensand marl, forming bowlders, Bell's Landing fossils .....8 to 10 feet
2. Gray, sandy, laminated clays.....20 to 25 feet
3. Sandy clay marl, fossiliferous.....4 to 5 feet
4. Laminated, sandy clays to water level.....10 feet

FIG. 5. *Section at Lower Peach Tree Landing, Alabama River.*

1. Sandy, laminated clays, top of bluff.....10 feet
2. Greensand marl, forming bowlders, Bell's Landing fossils .....8 to 10 feet
3. Laminated, sandy clays of gray color but with reddish layers.....20 to 25 feet
4. Bluish, sandy clay marl, Gregg's Landing fossils.....4 to 5 feet
5. Sandy clays of prevailing gray color, varying in degree of sandiness and coarseness of lamination. No fossils observed.50 feet
6. Fossiliferous greensand.....1 foot
7. Gray, sandy clays to water level.....10 feet

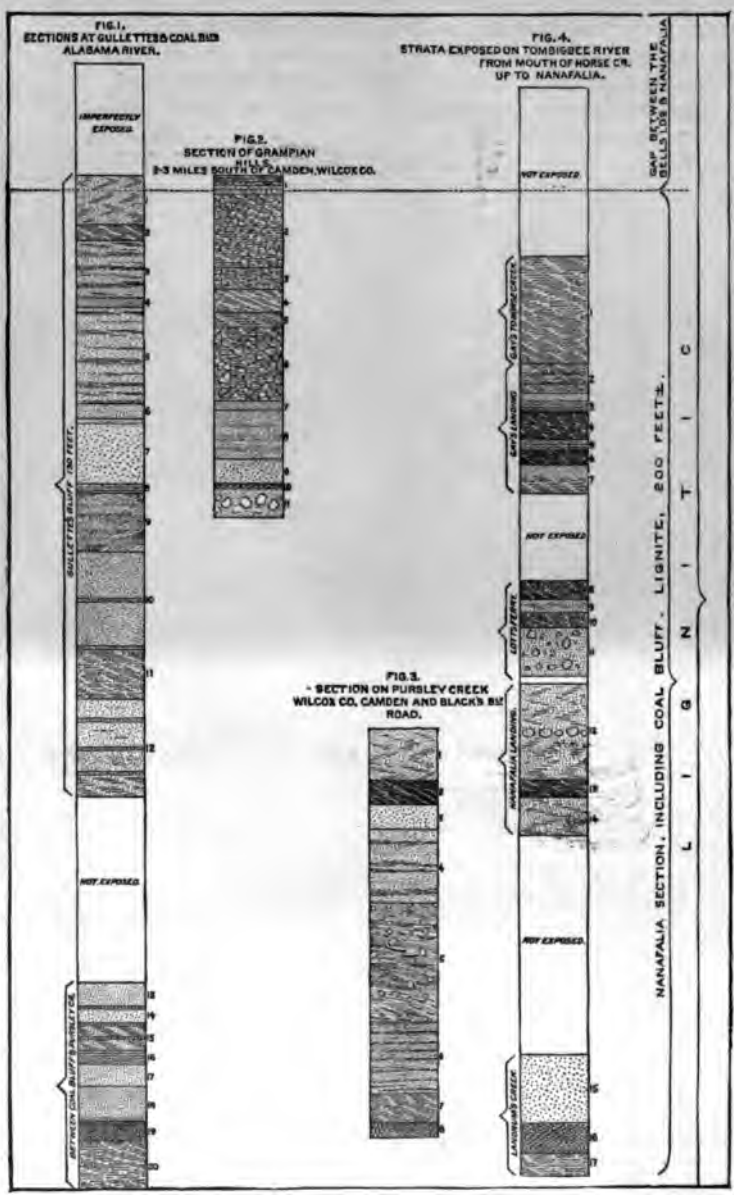
FIG. 6. *Section at Tuscahoma Landing and up to Shuquabowa Creek, Tombigbee River.*

1. Laminated sands, interstratified with clayey sheets, upper part; lower part, indurated sands with two lines of ferruginous, bowlder-like concretions, one at base, the other ten feet above .....30 feet
2. Light bluish gray, sandy clays, striped with somewhat harder projecting bands or ledges.....35 to 40 feet
3. Greensand marl, Bell's Landing fossils; three feet blue clay in middle .....6 to 7 feet
4. Bluish black, massive clay..... 2 feet
5. Sands passing into sandy clay below..... 5 feet
6. Light colored, cross-bedded sands above, with sands and clay interstratified below.....8 feet

FIG. 7. *Section at Wood's Bluff and Bashi Creek, Tombigbee River.*

1. Dark gray to brown and purple, sandy clays, lower beds of Hatchetigbee section
2. Bluish, sandy, fossiliferous clay, red on surface, hard ledge on top.....3 feet
3. Bluish, sandy clay (like 2), but not fossiliferous, passing into greensand below.....7 feet
4. Fossiliferous, clayey greensand.....3 feet
5. Greensand marl, with a stratum of ponderous oyster shells;

highly fossiliferous sands forming bowlders ..... 10 feet
6. Fossiliferous greensand, loose and easily washed out forming caves below the bowlders..... 8 feet
7. Thin bands of lignite over greenish, non-fossiliferous, clayey sands ..... 5 feet
8. Laminated, gray, sandy clays..... 3 to 4 feet
9. Lignite ..... 1 foot



Scale: 1 inch = 40 feet.

NANAFALIA AND COAL BLUFF SECTION OF THE LIGNITIC.

PLATE XXIV.

ILLUSTRATING THE NANAFALIA AND COAL BLUFF SECTIONS OF THE LIGNITIC.

FIG. 1. *Section at Gullette's Bluff and Coal Bluff, Alabama River.*

Gullette's Bluff.

1. Red loam, sand, &c., of Lafayette, at the top of the bluff..10 feet
2. Indurated, glauconitic clay.....8 feet
3. Gray, sandy clays, alternately thinly laminated and heavy bedded or massive .....12 feet
4. Very green, glauconitic sand .....2 feet
5. Gray, sandy clays, similar to No. 3 above.....20 feet
6. Fossiliferous, glauconitic sand, first of *Gryphæa thirsæ* beds.3 feet
7. Compact, yellowish sands with *Gryphæa thirsæ*, capped by hard ledge, forming vertical cliff.....13 feet
8. Indurated sands.....2 feet
9. White, cross-bedded sands.....12 feet
10. Bluish sands in a vertical cliff; contains *Gryphæa thirsæ*; indurated ledge in middle and at bottom of the bed.....20 feet
11. Bluish, clayey sands, with *Gryphæa*.....10 feet
12. Sands with *Gryphæa thirsæ*, traversed by several indurated ledges down to water level; darker colored and more clayey below .....20 feet

Between mouth of Pursley Creek and Coal Bluff.

13. Greensand. mouth of Pursley Creek.....5 feet
14. Sand capped indurated ledge.....3 feet
15. Clayey sands; indurated sandy ledges at top and in the midst .....6 feet
16. Indurated greensand.....3 feet
17. Softer greensand, out of which caves are washed.....5 feet
18. Greensand of firmer texture, with 1 foot of brownish sand at bottom .....8 feet
19. Lignite of Coal Bluff.....4 feet
20. Firm, gray, sandy clays appearing just above Coal Buff Landing .....10 feet

FIG. 2. *Section in Grampian Hills, 2 to 3 miles south of Camden, Wilcox County.*

1. Light colored sand and clayey rocks 2 feet, and 2 feet sandstone with shell casts.....4 feet
2. Gray clays, indurated, closely resembling Buhrstone.10 to 15 feet
3. Light colored, sandy clay rock, full of shell casts, chiefly *Turritella*.....5 feet

FIG. 2. *Section on the Alabama River.*

Coal Bluff.

1. Bluish greensand over lignite.
2. Coal Bluff lignite.....4 feet
3. Compact, clayey sand underlying lignite.

Burford's Landing.

4. Gray, cross bedded sands alternating with laminæ of gray clay, Burford's Landing.....10 feet

Walnut Bluff.

5. Light yellowish, cross bedded sands, Walnut Bluff.

Turkey Creek to Clifton.

6. Gray or bluish, sandy clays, forming river banks from mouth of Turkey creek to Clifton, of variable dip and hence of undetermined thickness.
7. Dark, gray sandy clays at Clifton and above, nearly to mouth of Dickson's Creek. The beginning of the Mathews's Landing beds.....10 feet

Matthews's Landing.

8. Bluish black, micaceous sands, highly fossiliferous.....5 to 6 feet
9. Yellowish gray, calcareous sands, indurating into bowlders.4 feet
10. Bluish black, micaceous sands, fossiliferous, compact and clayey below.....7 to 8 feet

Midway.

11. Black, calcareous clay overlying the Nautilus Rock.....5 feet
12. Gray, argillaceous limestone, with numerous large *Enclimatoceras Ulrichi*.....10 feet

FIG. 3. *Section on the Tombigbee River.*

Mouth of Beaver Creek to Naheola.

1. Coarse grained, micaceous sands, with projecting bowlders of indurated sand or sandstones, no fossils, thin clay partings at intervals, seen just below Tompkinsville.....20 feet
2. Cross bedded sands, just below Tompkinsville.....10 feet
3. Gray, sandy clays, alternating with ledges of indurated sand and thin clay partings, Tompkinsville Bluff, no fossils.....30 feet
4. Gray, sandy clays, with ledges of sandier texture and lighter color.....20 feet

PLATE XXV.

ILLUSTRATING THE OAK HILL, PINE BARREN SERIES, WHICH INCLUDES THE NANEOLA AND MATTHEWS'S LANDING, BLACK BLUFF, AND THE MIDWAY SECTIONS OF THE LIGNITIC.

FIG. 1. *Section at Oak Hill and on Pine Barren Creek.*

1. Cross bedded sands and thinly laminated clays, much weathered and with difficulty distinguished from the red loam &c. of the Lafayette.....25 feet
2. Gray, cross bedded sands, with thin laminæ of dark gray clay. These beds are much the same as the preceeding, but are much less weathered .....40 feet
3. Cross bedded and laminated sands, yellowish.....1½ feet
4. Thin bedded, gray, laminated clays, interstratified with thin ledges of cross bedded sands.....30 feet
5. Sands 1 foot, clays 1 foot, sands 1 foot.....3 feet
6. Gray clays interstratified with cross bedded sands.....6 feet
7. Gray, cross bedded sands.....3 feet
8. Gray clay, breaking up into cuboidal blocks, and interstratified with sandy ledges.....15 feet
9. Black to gray, micaceous sands, with the fossils of Matthews's Landing, dark at top, lighter and glauconitic below.....7 feet
10. Glauconitic sandy ledge, calcareous.....1 foot
11. Yellowish, calcareous sands, with phosphatic and white lime concretions; crustacean remains in upper 5 feet; several hard, shaly ledges.....12 feet
12. Glauconitic, sandy shales, with indurated ledge at top.....10 feet
13. Sandy, shaly beds, with indurated ledges.....6 feet
14. Hard, yellowish, sandy limestone, phosphatic.....3 feet
15. Yellowish, calcareous, clayey sands, with white lime concretions, grayer and more clayey below; Black Bluff fossils abundant.. 15 feet
16. Black calcareous clays, gray gray on weathered surfaces; Black Bluff fossils, especially in upper part. This forms basis of the prairie soils.....20 feet
17. Hard, grayish white limestone, used for chimneys, &c., containing a large *Nautilus*.....10 feet
18. Calcareous sands forming basis of the sandy praries.....6 feet
19. Hard, yellow, crystalline limestone, with Ostrea, *Turritella Mortoni* and *Venericardia planicosta*.....8 feet
20. Yellow, micaceous sands, with Ripley fossils seen on road above Palmer's Mill.....55 feet
21. Bluish gray, calcareous sands, with projecting sandy ledges, on Pine Barren Creek.....15 feet

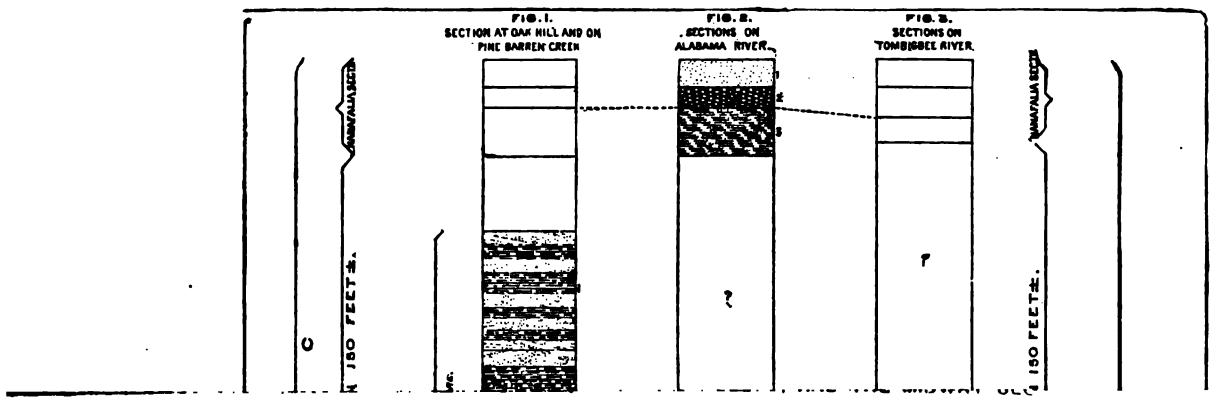


FIG. 1.
SECTION AT OAK HILL AND ON PINE BARREN CREEK
FIG. 2.
SECTIONS ON ALABAMA RIVER.
FIG. 3.
SECTIONS ON TOMBIGBEE RIVER.
NANAFALIA BEDS
150 FEET±.
C
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P

5. Black, sandy clay, with indurated ledge of greensand above, in all.....3 feet
6. Greensand marl, capped with hard ledge, ferruginous.....3 feet
7. Black, slaty clay, recurring at all the bluffs above this to Black Bluff .....10 feet

Black Bluff.

8. Yellowish clay at top of bluff. This clay is the basis of the Flatwoods .....30 feet
9. Black, slaty clay, strongly calcareous, fossilferous (Black Bluff fossils).....40 feet
   The lower part of this division is covered with singularly shaped concretions of limonite.
10. Brownish, shaly clay to the water level.....10 feet

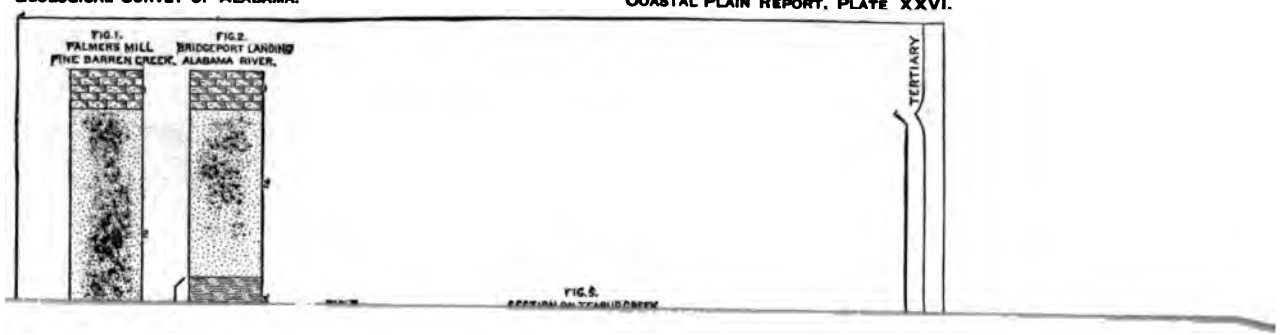


FIG.1.
PALMERS MILL
PINE BARREN CREEK.
FIG.2.
BRIDGEPORT LANDING
ALABAMA RIVER.
TERTIARY
FIG.3.

PLATE XXVI.

ILLUSTRATING THE RIPLEY FORMATION OF THE CRETACEOUS GROUP, ALABAMA AND TOMBIGBEE RIVERS.

FIG. 1. *Palmer's Mill, on Pine Barren Creek.*

1. Hard, yellow, crystalline limestone, with *Ostrea*, corals, *Turritella Mortoni*, *Venericardia planicosta*, &c. ..... 8 feet
2. Yellow, micaceous sands, with Ripley fossils, seen on road above Palmer's Mill ..... 55 feet
3. Bluish gray, calcareous sands, with several projecting sandy ledges, to level of Pine Barren creek ..... 15 feet

FIG. 2. *Bridgeport Landing, Alabama River.*

1. Yellow, crystalline limestone, seen in Camden-Bridgeport road.
2. Yellowish, micaceous sands, forming basis of the hills back of the Bridgeport bluff.
3. Yellow, clayey sands, top of bluff at Bridgeport Landing. . 10 feet
4. Coarse, yellow sands ..... 10 feet
5. Laminated, gray clays ..... 1 foot
6. Ledge of dark gray, sandy clay ..... 1 foot
7. Dark gray, nearly black, sandy, micaceous clays, with hard, projecting, sandy ledges at intervals of 3 to 4 feet ..... 22 feet
8. Projecting, sandy ledge ..... 1½ feet
9. Dark gray, sandy clays ..... 3 feet
10. Sandy ledge ..... 1 foot
11. Dark gray, sandy clays, with two hard, sandy ledges, to water level ..... 10 feet

FIG. 3. *Canton Landing, Alabama River.*

1. Yellow sands, forming basis of the fertile soils of the Canton Bend.
2. Yellowish gray, micaceous, and calcareous sands, in beds averaging 3 to 5 feet in thickness and separated by hard, sandy ledges, which shale off on weathering; these beds appear at intervals on hillside immediately back of the river bluff, being in part covered by debris ..... 100 feet
   In places the clayey sands have a dark blue color.
3. Yellow, calcareous, sandy clays, like the preceding, with hard ledges above and below; top of river bluff ..... 10 feet
4. Bluish, micaceous, sandy clays, the counterpart of those at Bridgeport, with two projecting, sandy ledges ..... 12 feet
5. Light gray, calcareous sands, holding indurated, irregular masses, phosphatized shell casts, &c.; sandstone ledge at base.... 6 feet
6. Bluish gray, sandy clay, 5 feet thick, underlaid by more sandy bed, with phosphatized shell casts, nodules, &c. ..... 8 feet

7. Bluish, argillaceous limestone, with *Exogyra*, *Gryphæa*, and phosphatic casts.....3 feet
8. Calcareous sands, with variety of fossils.....3 feet

FIG. 4. *Foster's Creek, in Gee's Bend, Alabama River.*

1. Yellowish, calcareous, sandy clay soil, with growth of red cedars.
2. Dark gray, micaceous, sandy clays, like those of Bridgeport, with hard, sandier ledges of lighter color at intervals of 5 to 6 feet. The lowermost of these beds contains the small Moscow *Gryphæa*.....30 feet
3. Impure limestone, glauconitic, with phosphatized shell casts, &c.....5 feet
4. Coarse, calcareous sandstone ledge.....2 feet
5. Bluish, sandy, argillaceous limestone, no fossils at top, but filled in its lower and middle parts with shells and phosphatized shell casts. The materials of this bed vary from argillaceous limestone to calcareous sands.....20 feet
6. Brown, phosphatic limestone.....1 foot
7. Argillaceous sandstone.....1 foot

FIG. 5. *Section on Tear Up Creek, Wilcox County, Alabama River.*

1. Yellow sands at base of McNeill's Mountain.
2. Dark bluish gray, sandy, micaceous clays, with hard, projecting ledges at intervals of 3 or 4 feet. These beds are exposed in channel of Tear Up Creek between the river and the foot of McNeill's Mountain, distance about 1 mile. The thickness not measured, but here placed equal to that noticed at Canton Landing.....100 feet
3. Ferruginous, sandy marl, full of Ripley fossils.....3 feet
4. Firm white limestone; no fossils observed.....6 feet
5. White limestone, with a few fossils.....2 feet
6. Sandy, calcareous beds, with fine fossils.....4 feet
7. Sandy, indurated limestone ledge.....1 to 2 feet
8. Calcareous limestone, with *Exogyra costata*, &c.....8 feet

FIG. 6. *Prairie Bluff and hill to the northeast, Alabama River.*

1. Yellowish, calcareous, and micaceous sands, with hard, sandy ledges at intervals of 4 to 5 feet, forming the hill northeast of Prairie Bluff towards Rehoboth. In some places, where less exposed to weathering, the color of the sandy clays is dark bluish, like those of Bridgeport. The strata of this hill are in appearance identical with those above the river bluff at the old Canton Landing: not a continuous section,

75 to 100 feet, perhaps more

2. Impure limestone, holding phosphatized shell casts, &c., outcropping on the bluff north of warehouse; estimated thickness, 12 to 15 feet
3. Bluish limestone, with shell casts and *Exogyra costata*, *Gryphæa vesicularis*, &c., forming top of bluff below warehouse; two hard ledges in it ..... 20 feet
4. Sands traversed by indurated bands of calcareous sand, holding *Exogyra costata* and *Gryphæa vesicularis* chiefly. The sands are white above and dark blue near water level, but the blue sands become white where they crop out up the river near the top of the bluff. Sands contain great numbers of *Ostrea falcata*, 50 to 60 feet

FIG. 7. *Below Moscow, on the Tombigbee River.*

1. Black, shaly clay, devoid of fossils, joints filled with calcite, at mouth of Sucarnochee Creek ..... 6 to 8 feet
2. Dark blue, shaly, argillaceous limestone and thin, projecting, harder ledges ..... 30 feet
3. Ledges of small *Gryphæa* shells. ..... 1 foot
4. Hard, impure limestone, with *Exogyra costata* and *Gryphæa vesicularis;* irrregular, concretionary, sandy ledge above, with comminuted shells, below which a projecting ledge, with many phosphatized shell casts ..... 15 feet

PLATE XXVII.

ILLUSTRATING THE PHOSPHATIC GREENSANDS (TOMBIGBEE SAND) AT BASE OF THE ROTTEN LIMESTONE, TOGETHER WITH THE UPPER STRATA OF THE RUTAW FORMATION OF THE CRETACEOUS GROUP.

FIG. 1. *Bluff at Erie, Tuscaloosa River.*

1. Rotten Limestone of the usual character.....80 feet
2. Indurated ledge, calcareous sand, glauconitic and phosphatic, containing oyster shells.....7 feet
3. Yellowish sands, containing shells in upper part.....8 feet
4. Ledge of shells.....1 foot
5. Yellowish, glauconitic sands; more glauconitic below.....5 feet
6. Sandy ledge, with shells.....1 foot
7. Greensand, cross bedded.....4 feet
8. Laminated, blue clay, projecting.....2 feet
9. Phosphatic greensand.....1 foot

FIG. 2. *McAlpine's Ferry, Tuscaloosa River.*

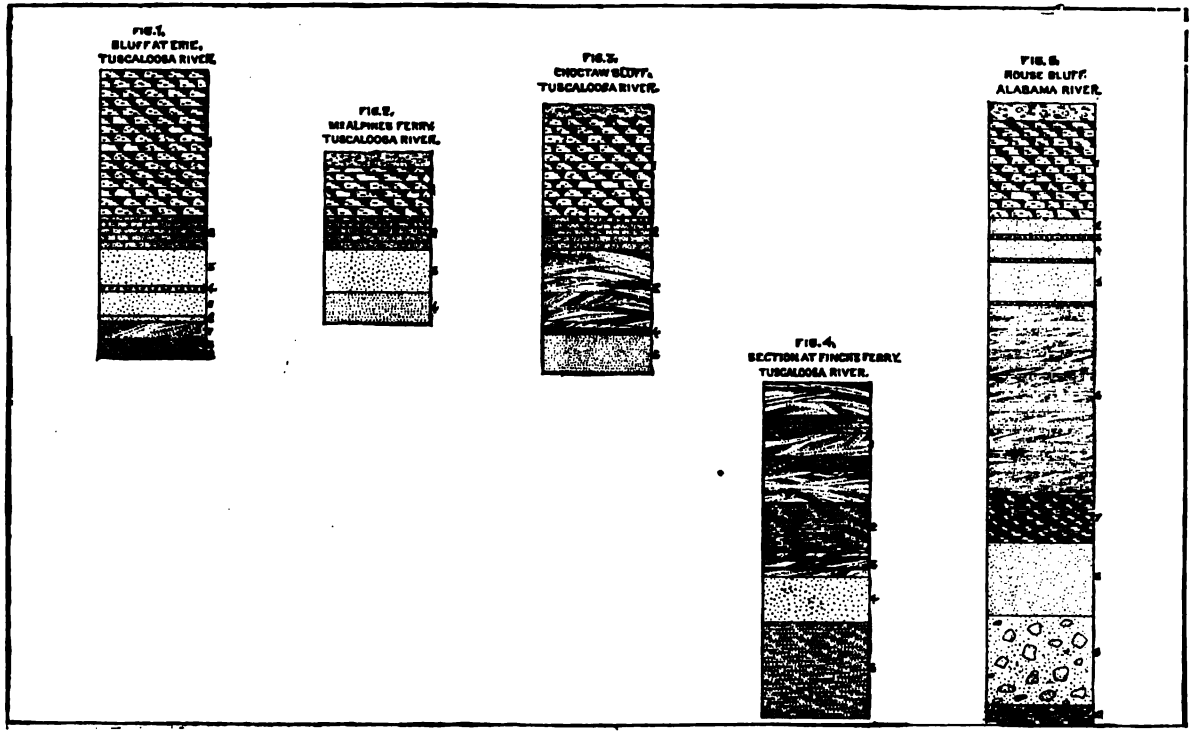
1. Rotten Limestone of variable thickness, with covering of Lafayette.
2. Calcareous sands, indurated, containing shells, mostly oysters.. 6 to 8 feet
3. Sands.....8 to 10 feet
4. Greensand to water level.....6 feet or more

FIG. 3. *Choctaw Bluff, Tuscaloosa River.*

1. Rotten Limestone, with Inocerami and reptilian bones, covering of Lafayette.....20 feet
2. Indurated calcareous sands, full of shells, glauconitic; upper part=the "Concrete Sand" of Winchell.....6 to 7 feet
3. Yellowish, cross bedded sands, containing oyster shells in upper part, more glauconitic and devoid of fossils below.....15 feet
4. Glauconitic sands and small oyster shells.....1 foot
5. Phosphatic greensand.....6 to 8 feet

FIG. 4. *Section at Finch's Ferry, Tuscaloosa River.*

1. Yellowish, cross bedded sands, with indurated bands at intervals; contains a few casts of shells, mostly oysters, and pieces of silicified wood.....25 feet
2. Laminated, blue clays, with sand between the laminæ....10 feet
3. Alternations of cross bedded sand and blue, laminated clay.5 feet
4. Bluish, glauconitic sand.....10 feet
5. Laminated, blue clays, the laminæ separated by sand.....20 feet



Scale: 1 inch = 40 feet.

PHOSPHATIC GREENSANDS AT THE BASE OF THE ROTTEN LIMESTONE.

FIG. 5. *House Bluff, Alabama River.*

1. Rotten Limestone.....20 feet
2. Greensand, with phosphatic nodules.....4 feet
3. Bed of shells in sand.....1 foot
4. Light colored sands, with irregular deposits of shells and shell bed at base.....5 feet
5. Sands, with layer of shells at base.....9 feet
6. Alternating beds of horizontally laminated and cross bedded sands, yellow (glauconitic), the separate beds from 1 to 2 feet thick, marked with streaks deeply colored by iron.....40 feet
7. Laminated clays (soapstone), devoid of fossils.....10 feet
8. Blue, micaceous sands, no fossils observed.....15 feet
9. Light colored sands, with large, bowlder-like concretions..20 feet
10. Alternations of laminated clays and blue sands to water level.

PLATE YXVIII.

GENERAL SECTION OF TERTIARY AND CRETACEOUS STRATA OF ALABAMA, AS EXPOSED ALONG THE ALABAMA, TOMBIGBEE, AND TUSCALOOSA RIVERS

COLUMN 1. *Exposures inland near Alabama River. (Supplementary to Alabama River section.)*

Hills back of Yellow Bluff.

1. Gray, sandy clays, alternating with cross bedded sands, seen in hill back of Yellow Bluff; barometric measurement....90 feet
2. Gray, sandy clays, alternating with cross bedded sands, like the preceding; seen in hill at top of Yellow Bluff.....40 feet
3. Greensand marl, Wood's Bluff.....6 to 15 feet
4. Gray sandy clays of purple tinge, including four or five thin seams of lignite. Top of Yellow Bluff.....40 feet

Grampian Hills.

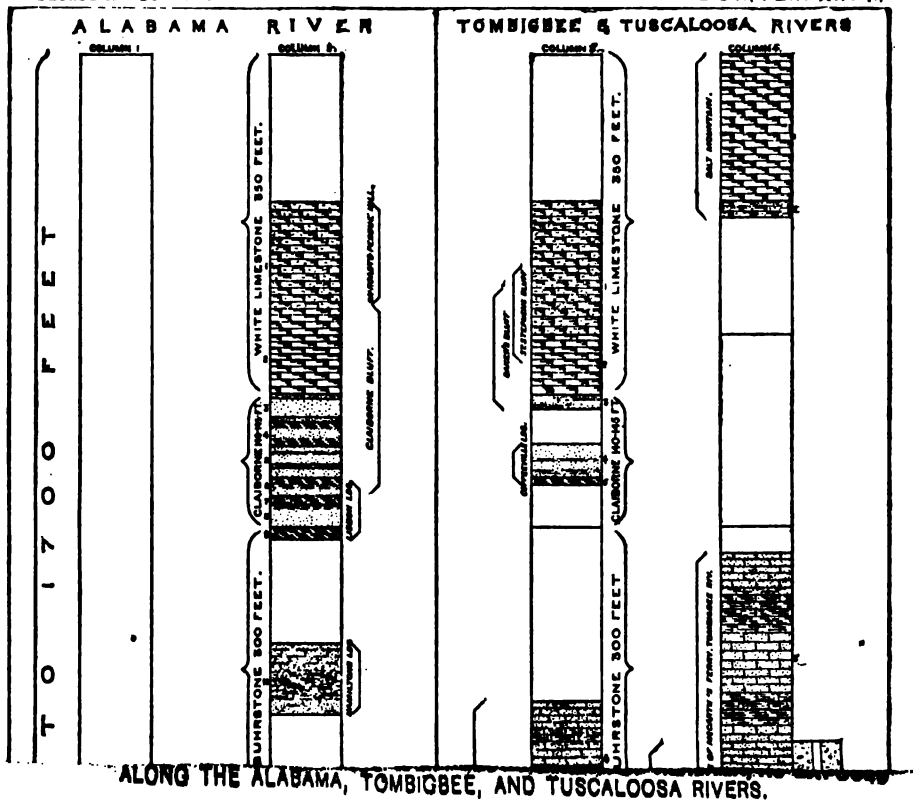
5. Gray, sandy clays, indurated, in part glauconitic, and filled with shell casts, chiefly of Turritella, in part closely resembling Buhrstone clays.....47 to 50 feet
6. Glauconitic sands, with *Gryphæa thirsæ*, several indurated bands .....25 feet

On Pursley Creek.

7. Glauconitic sands, with *Gryphæa thirsæ*, clayey above.....12 feet
8. Laminated sand and sandy clays .....15 feet
9. Yellowish gray, cross bedded sands, indurating, with bowlders, inclosing lenticular sheets of clay.....25 feet
10. Gray sands and clays, interstratified, glauconitic; lignite at base; seen in Pursley Creek.....20 feet

Oak Hill, Graveyard Hill, and Pine Barren Creek.

11. Gray, sandy clays, cross bedded sands, and thin, laminated clays in many alternations.....108 feet
12. Gray clay, breaking into cuboidal blocks, 15 feet, passing into black clay marl, Matthews's Landing.....23 feet
13. Yellowish, calcareous sands and sandy shales, with hard ledges and 3 feet hard, yellowish, phosphatic, sandy limestone at base.....31 feet
14. Yellow, calcareous clays, passing below into black, all holding Black Rluff fossils.....35 feet
15. Argillaceous white limestone; Nautilus Rock 10 feet, with 6 feet calcareous sands below.....16 feet
16. Crystalline limestone and Turritella Rock.....8 to 9 feet



ALONG THE ALABAMA, TOMBIGBEE, AND TUSCALOOSA RIVERS.

17. Yellowish, micaceous sand with Ripley fossils.....55 feet
18. Bluish gray, calcareous sands, hard, projecting layers.....15 feet

Near Vineton, Autauga County.

19. Thinly laminated, white and pink and purple clays, with small percentage of pink, purple, and yellow sand.....30 feet
20. Purple and mottled clays 12 feet, red sands 5 feet, and white and yellow, laminated clays 8 feet.....25 feet
21. Variegated pink and micaceous sands.....6 feet
22. Mottled, yellow and purple, sandy clays and sands, on the banks of Mulberry Creek.....20 feet

Soap Hill, Bibb County.

23. Clayey sands in several ledges.....10 feet
24. Cross bedded, yellowish white sands, indurating into sandstones at intervals.....30 feet
25. Laminated, gray clay, with partings of sand 10 feet, overlying 40 feet of laminated clays and cross bedded sands.....50 feet
26. Laminated, gray, sandy clays, with leaf impressions, sand at base.....20 feet

Near Tuscaloosa.

27. Variegated, purple sands, sheet of ferruginous sandstone on top.. 8 feet
28. Purple clay, with partings of sand.....10 feet
29. Gray, yellow sands and clays, ferruginous ledge on top....8 feet
30. Thin bed of lignite in clays, over gray mass. Not seen, about 20 feet
31. Purple clays, with two ledges of sandy iron ore.....40 to 50 feet

COLUMN 2. *Section exposed on Alabama River.*

Marshall's Landing to Lisbon.

1. *Vicksburg.* White Limestone, with *Orbitoides Mantelli*, hill back of Claiborne, also back from river, from Marshall's Landing to Gainestown.....at least 140 feet
2. *Jackson.* Argillaceous White Limestone, with bones of *Zeuglodon Cetoides*, phosphatic nodules, and marls, from Claiborne to Marshall's Landing.....60 feet
3. Scutella bed, followed by coarse, ferruginous sands, of which 17 feet is highly fossiliferous; hard, sandy ledge at base....30 feet
4. Calcareous clay, alternating with greensand containing *Ostrea sellæformis*.....25 feet
5. Light gray, calcareous sands, traversed by hard, sandy ledges, clayey in part, *Ostrea sellæformis*, characteristic greensand, and shells at base.....35 feet

6. Blue clay, passing into greensand, upper half with few fossils, lower half highly fossiliferous.....22 feet
7. Calcareous, clayey sands.....9 feet
8. Coarse ferruginous marl 3 feet, followed by 20 feet of light yellow sands, few fossils.....23 feet
9. Bluish, jointed clay .....12 feet

Hamilton's Landing.

10. Light colored, aluminous sandstones, claystones, and silicious sandstone.....75 feet

Yellow Bluff, Bell's Landing, and Lower Peach Tree.

11. Reddish, cross-bedded sands. 2 feet lignite at base.....22 feet
12. Laminated, sandy clays, gray color.....15 feet
13. Yellow sands, passing below into gray, laminated, sandy clays.....25 feet
14. Greensand marl, Bell's Landing.....10 feet
15. Gray, laminated, sandy clays 22 to 25 feet, passing into clay marl, Gregg's Landing, 5 feet.....30 feet
16. Sandy clays of prevailing gray color, varying in degree of sandiness and coarseness of lamination, 1 foot greensand marl at base.....50 feet
17. Gray, sandy clays .....10 feet

Gullette's Landing.

18. Gray, sandy clays, alternately thin laminated, and heavy bedded; indurated by glauconitic clay on top and greensand bed in middle.....37 feet
19. Glauconitic sands, with *Gryphæa thirsæ*, indurated ledges passing through beds.....18 feet
20. White, cross-bedded sands.....12 feet
21. Bluish, clayey, glauconitic sands, with *Gryphæa thirsæ*, several hard legdes.....50 feet

Parsley Creek to Coal Bluff.

22. Glauconitic, clayey sands of varying degree of hardness, bed of lignite 4 feet (Coal Bluff) at base.....35 feet
23. Gray, sandy clays.....10 feet

Burford's Landing.

24. Gray clay, cross-bedded sands, Burford's Landing.....10 feet

Walnut Bluff to Clifton.

25. Gray, sandy clays forming river banks from Walnut Bluff to Clifton.....35 (?) feet

Matthews's Landing.

26. Black, sandy clay marl, micaceous, Matthews's Landing...20 feet

Midway to Prairie Bluff.

27. Black clay, Midway..... 5 feet
28. Argillaceous White Limestone (Nautilus Rock).....10 feet
29. Crystalline limestone (*Turritella*) back of Bridgeport.
30. Yellowish, micaceous sand (Ripley fossils) at Bridgeport and hills back of landing..... 55 feet
31. Dark bluish gray, sandy, micaceous clays, weathering into yellowish shales, with indurated, sandy, projecting ledges at intervals of 5 to 10 feet throughout whole thickness, exposed at Bridgeport, Tear Up Creek, Canton Landing, and hills back of Prairie Bluff, and in Gee's Bend.....100 feet
32. Bluish, argillaceous limestone, with phosphatized shell casts, &c., Ripley formation..... 30 to 35 feet
33. Sands of various colors, dark blue, gray to white, traversed by indurated bands of calcareous sands with Cretaceous shells .....80 feet

Rotten Limestone, Bridgeport to House Bluff.

34. Highly argillaceous limestone, with ledges holding many shells, *Ostrea Gryphæa*, *Exogyra*.....1,000 feet

House Bluff.

35. Hard calcareous sands, with fossils, strongly phosphatic in part..... 20 feet
36. Alternating layers of horizontally laminated and cross-bedded, yellowish (glauconitic) sands.....40 feet
37. Laminated, blue clays.....10 feet
38. Blue, micaceous sands.....15 feet
39. Light colored, micaceous sands..... 20 feet
40. Laminated clays and blue sands, thickness not determined.

COLUMN 3. *Section exposed on the Tombigbee (including the Tuscaloosa) River.*

St. Stephens and Baker's Bluff.

1. *Vicksburg.* White Limestone with *Orbitoides Mantelli*, forms upper 70 feet of Saint Stephens Bluff, upper part of Baker's Hill, and greater part of river bluffs, down to Oven Bluff....140 feet
2. *Jackson.* Argillaceous White Limestone lower part of Saint Stephens and Baker's Bluff .....60 feet

3. Scutella bed, underlaid by course greensand and Claiborne fossiliferous sands. ... . 15 feet

Coffeeville Landing

4. Yellowish gray, calcareous sands, with *Ostrea sellæformis*, clayey in part, traversed by hard, sandy ledges, greensand with comminuted shells at base.....35 feet
5. Bluish clay... ..... 7 feet

Hatchetigbee to mouth of Bashi Creek.

6. Aluminous sandstones, claystones, &c., of jointed structure, forming at White Bluff a perpendicular cliff.....115 feet
7. Brown clays, sandy, non-fossiliferous, 30 feet, followed by 3 feet marl and 15 feet purplish brown, sandy clays; then 28 feet of sands, striped with brown clays and inclosing two beds with marine shells; in all.....75 to 76 fee
8. Dark gray, sandy clays, with brown or purple, sandy clays. Very few fossils exposed at Davis's Bluff, White's Bluff, and McCarthy's Bluff..... ..... 100 feet
9. Clayey marl, passing into a greensand marl 18 feet thick..31 feet
10. Gray, clayey sands, with four or more thin seams of lignite.25 feet

Tuscahoma to Shuquabowa Creek.

11. Laminated sands and indurated sands, with bowlders .. 30 feet
12. Gray, sandy clays, striped with somewhat harder, projecting ledges .....35 to 40 feet
13. Greensand marl (Bell's Landing) ..... 7 feet
14. Sandy, laminated clays ..... 15 feet

Horse Creek to Gay's Landing.

15. Gray, sandy clays, rather thin bedded; hard, sandy ledge at base.....28 feet
16. Glauconitic sands and clays, with *Gryphæa thirsæ*.. ..... 18 feet

Lott's Ferry at Nanafalia.

17. Glauconitic sands, with *Gryphæa thirsæ*, at Lott's Ferry, Eureka Landing, and Nanafalia Landing ..... 35 feet
18. Black clay, passing into greensand marl, with *Gryphæa thirsæ* ..... 18 feet

Landrum's Creek.

19. Black, micaceous, glauconitic sands ..... 15 feet
20. Lignite 7 feet and 5 feet gray clay below ..... 12 feet

Tompkinsville to Naheola.

21. Gray, sandy clays, cross-bedded sands and laminated clays in many alternations.....80 feet
22. Greensand marl (Naheola), with black clay below.....20 feet

Naheola to Black Bluff.

23. Between Naheola and Black Bluff, black clay..thickness unknown
24. Yellowish clays 30 feet, underlaid by 50 feet of black and dark brown, slaty, fossiliferous clays, Black Bluff fossils.....80 feet

Moscow.

25. Dark blue or black, sandy clays, with indurated bands, calcareous below, passing into an argillaceous limestone 16 to 18 feet. with phosphatized shell casts.....55 feet

Rotten Limestone, Moscow to Choctaw Bluff.

.6. Argillaceous limestone, with hard ledges, holding many shells (*Ostrea, Exogyra, Gryphæa*).....1,000 feet

Choctaw Bluff to Big Log Shoals.

27. Hard, calcareous sands, highly fossiliferous, 6 to 8 feet; thin, yellow, cross-bedded sands, 15 feet; and below this a phosphatic greensand, 8 to 10 feet.....about 25 feet
28. Cross-bedded, glauconitic sands, with thin clay partings, yellowish color prevailing.....40 feet
29. Dark gray, laminated, sandy clays, alternating with bluish sands.....15 to 20 feet
30. Laminated sands and clays, alternating with cross-bedded sands.....40 (?) feet
31. Compact, micaceous sands, cross-bedded sands, laminated clays, in many alternations, including two small beds of pebbles and thin bed of lignitic matter.....60 (?) feet

White's Bluff.

32. Purple and mottled clays, 10 feet, with 15 feet of yellow, micaceous sands below.....25 feet

Steele's Bluff.

33. Purple and mottled clays, 10 feet, with 10 feet light yellow, coarse, cross-bedded pebbly (chert) sands.....20 feet

Williford's.

34. Purple and mottled clays.....10 feet

Mrs. Prince's.

35. Purple and mottled clays ..... 10 feet

Saunders's Ferry to Tuscaloosa.

36. Dark gray, laminated clays, sandy partings, 25 feet, and gray sands, indurated, 15 feet, at Venable's and near Saunders's Ferry. ..... 40 feet
37. Sandy clays, with leaf impressions, black scales like graphite, fragments of lignitized stems.

COLUMN 4. *Exposures inland near Tombigbee and Tuscaloosa Rivers. (Supplementary to the Tombigbee River section.)*

Salt Mountain

1. White limestone, in part crystalline, filled with masses of coral ..... 150 feet
2. Orbitoidal White Limestone ..... 20 feet

Hill west of McCarthy's Ferry.

3. Aluminous sands, indurated clays or claystones, silicious sandstones, &c., forming hills west of McCarthy's Ferry, in Choctaw county, 270 feet in one exposure, with 15 feet laminated clays at base; in all ..... 285 feet

Bladen Springs boring.

4. Loose surface materials, varying slightly in color and texture, 80 feet
5. Alternations of blue and sandy marl (clay) with indurated blue ledge 5 feet thick at base ..... 81 feet
6. Soft, clayey marl ..... 23 feet
7. Greensand, with shells, 3 feet, followed by 22 feet alternating hard and soft beds, the latter fossiliferous, water-bearing, 25 feet
8. Marls or blue clays ..... 46 feet
9. Brown and blue marls (clays) in many alternations (lignitic?) 21 feet
10. Blue marls or clays, with 2 feet of greensand at base ..... 61 feet
11. Lignite, 5 feet, followed by 19 feet of brown, tough marl (clay) 24 feet
12. Blue, sandy marl, with many varieties of shells; *Venericardia planicosta* recognized ..... 23 feet
13. Blue, sandy marl (clay) ..... 58 feet
14. Brown marl (clay) 5 feet, with 32 feet blue marl below ..... 37 feet
15. Greensand marl, 9 feet, followed by 37 feet of blue marl (clay.) At 500 feet water was struck, which flowed 10 feet above surface ..... 46 feet

16. Brown clay marl, 19 feet, followed by 15 feet blue clay, with greensand, containing shells..... ....34 feet
17. Brown marl, resembling soapstone; contains shells; stream of water near bottom which flowed 30 feet above surface...50 feet
18. Gray, sandy marl, with shells .....15 feet
19. Gray, sandy marl, with shells; more clayey than preceding, 64 feet
20. Very tough, blue marl (clay), at base of which a thin layer of white sand and then a thin layer of greensand ..... 71 feet
21. Brown marl (clay) 5 feet, followed by alternating beds of clay and sand, mostly sand (*first salt water*).....20 feet
22. Alternations of gray and brown sand, with marl (clay)....26 feet
23. Tough, blue marl (*big vein of salt water*) ....13 feet
24. Sand and clay alternating .....14 feet
25. A kind of white limestone(?) containg mica, passing below into 3 feet blue, sandy marl, containing shells.....28 feet
26. Blue marl (clay) 14 feet, followed by 14 feet of blue marl and sand, numerous shells ....28 feet
27. Marl 12 feet with streaks of sand, followed by brown sand and blue marl, 12 feet.....24 feet
28. Greenish rock, chalky above, hard below.....11 feet
29. Sandstone 4 feet, followed by 25 feet quicksand, of white, blue, and gray colors (*strong stream of salt water*)..... ..29 feet
30. Marls or clays, mostly of grayish or light brown colors, with several ledges of extremely hard rock, e. g., one 2 feet thick at 966 feet, one 1 foot thick at 971 feet, one 3 inches thick at 978 feet, one 1 foot thick at 1000 feet.....137 feet
31. Tough black clay, 2 feet, followed by 99 feet of dark blue clay, some of it quite hard and firm; some very soft and sticky, 101 feet
32. Snuff colored clay, soft and sticky.....13 feet
33. Gray sand and shells 12 feet, followed by 5 feet soft, sandy clay, 17 feet
34. Hard ledge 4 inches at top, below which 125 feet of moderately hard, grayish or blue rock, with scarcely any change in color or texture, to bottom of boring; no shells observed; Rotten Limestone..... .... probably 125 feet

Livingstone artesian well boring.

35. Soft, blue, argillaceous Rotten Limestone, thickly set with shells and containing iron pyrites..... .....180 feet
36. Hard, white limestone, with few shells .....50 feet
37. Hard, blue limestone 7 feet, followed by 68 feet of pure, bluish white limestone, with few if any shells.....75 feet
38. Very hard, white limestone, stratum of oyster shells near top, 55 feet

39. Light blue limestone, not so hard as preceding .....47 feet
40. Bluish brown limestone, filled with small shells, rather sandy, 58 feet
41. Hard, white limestone.....105 feet
42. Soft, blue limestone, 2 feet brown rock at top.....22 feet
43. Rather soft, brownish blue limestone .....78 feet
44. Very soft, blue limestone, hard ledge at top.....11 feet
45. White limestone, moderately soft, with occasional slight changes in color and hardness.....250 feet
46. Hard sandstone 6 feet, 10 feet sand, water-bearing, and 1 foot sandstone .....17 feet
47. Coarse greensand 38 feet, sandstone 2 feet, greensand 25 feet, sandstone 2 feet, and greensand again 18 feet, water-bearing at 1,005 feet .....85 feet
48. Fine greensand, flint layer on top .....10 feet

Strata of Tuscaloosa formation.

Near Havana.

49. Yellow sand and pebbles 10 feet, overlying 30 feet of variegated, pink and purple, micaceous, cross-bedded sands, near Havana .....40 feet

Big Sandy Creek.

50. Purple and mottled clays seen along road leading up hill from Big Sandy Creek .....50 feet
51. Light yellow sands and pebbles 15 feet, with 8 feet dark gray, laminated clay, with lignitized trunk, Big Sandy Creek..23 feet

Little Sandy Creek.

52. Yellow, micaceous sands, overlying dark gray, micaceous, laminated clays .....8 feet
53. (Belongs to a recent formation.)

Tuscaloosa City.

54. Dark gray, laminated clays, with leaf impressions.....8 feet
55. Light colored, sharp, cross-bedded sands .....20 feet

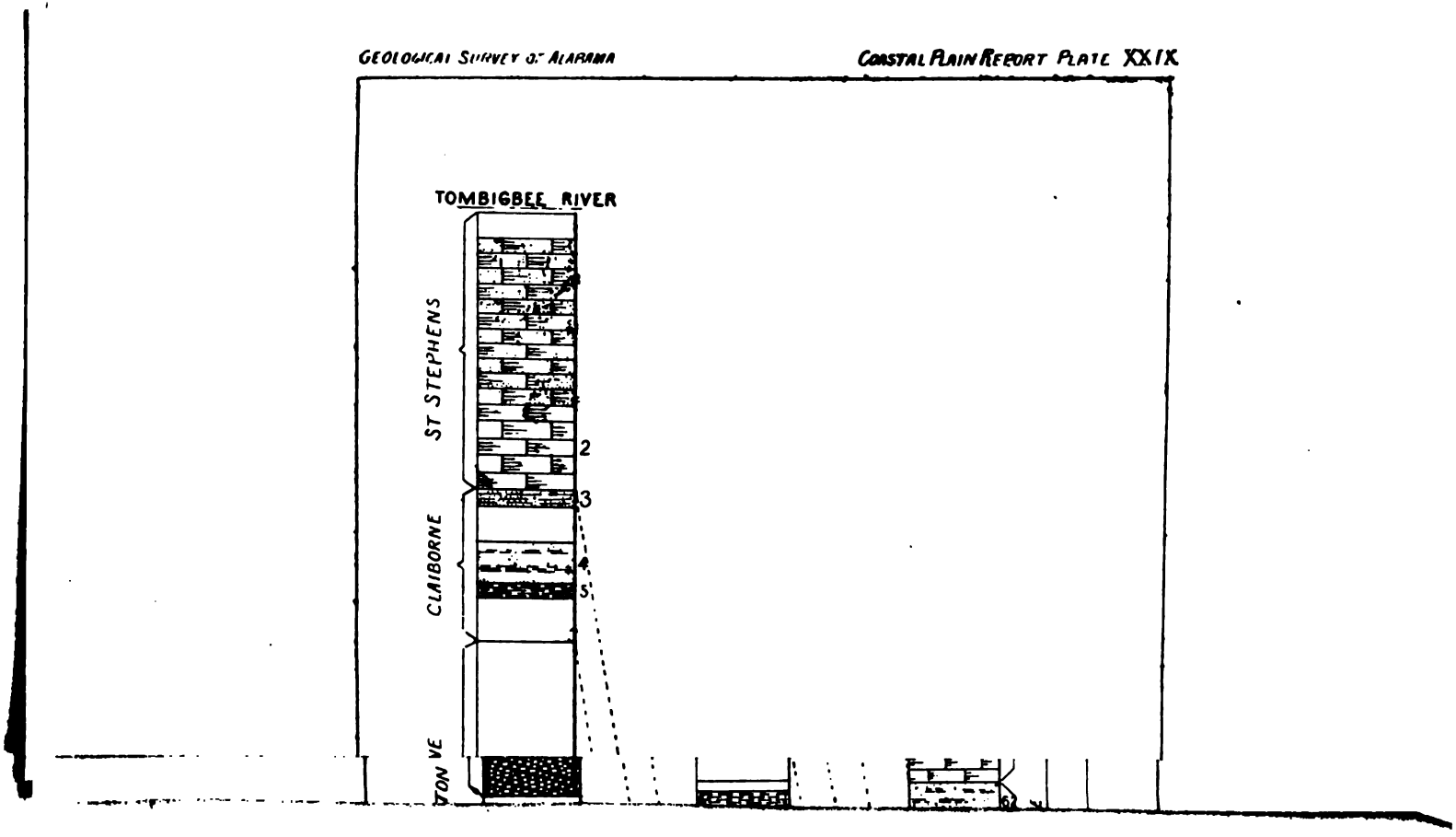

TOMBIGBEE RIVER
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PLATE XXIX.

GENERAL SECTION EXPOSED ALONG THE ALABAMA RIVERS.

COLUMN 1, *Tombigbee River.*

1. *Vicksburg.* White Limestone with Orbitoides Mantelli, forms upper 70 feet of Saint Stephens Bluff, upper part of Baker's Hill, and greater part of river bluffs down to Oven Bluff....140 feet
2. *Jackson.* Argillaceous White Limestone lower part of Saint Stephens and Baker's Bluffs..... 60 feet
3. Scutella beds, underlaid by coarse greensand and Claiborne fossiliferous sands.....15 feet
4. Yellowish gray, calcareous sands, with *Ostrea sellæformis*, clayey in part, traversed by hard, sandy ledges, greensand, with comminuted shells at base.....35 feet
5. Bluish clay.....7 feet
6. Aluminous sandstones, claystones, &c., of jointed structure, forming at White' s Bluff a perpendicular cliff.....115 feet
7. Brown clays, sandy, non-fossiliferous, 30 feet, followed by 3 feet marl and 15 feet purplish brown, sandy clays; then 28 feet of sands, striped with brown clays and inclosing two beds with marine shells; in all.....75 to 76 feet
8. Dark gray, sandy clays, striped with brown or purple, sandy clays. Very few fossils exposed at Davis's Bluff, White's Bluff and McCarthy's Bluff.....100 feet
9. Clayey marl, passing into a greensand marl 18 feet thick (Wood's Bluff marl).....31 feet
10. Gray, clayey sands, with four or more thin seams of lignite .....25 feet
11. Laminated sands and indurated sands, with bowlders.....30 feet
12. Gray, sandy clays, striped with somewhat harder, projecting ledges .....35 to 40 feet
13. Greensand marl (Bell's Landing).....7 feet
14. Sandy, laminated clays.....15 feet
15. Gray, sandy clays, rather thin bedded; hard, sandy ledge at base .....28 feet
16. Glauconitic sands and clays, with *Gryphæa thirsæ*.....18 feet
17. Glauconitic sands, with *Gryphæa thirsæ*, at Lott's Ferry, Eureka Landing, and Nanafalia Landing.....35 feet
18 Black clay, passing into a greensand marl, with *Gryphæa thirsæ* .....18 feet
19. Black, micaceous, glauconitic sands .....15 feet
20. Lignite 7 feet and 5 feet gray clay below..... 12 feet
21. Gray, sandy clays, cross-bedded sands and laminated clays in many alternations.....80 feet

22. Greensand marl (Naheola), with black clay below.....20 feet
23. Between Naheola and Black Bluff, black clays, thickness unknown
24. Yellowish clays 30 feet, underlaid by 50 feet of black and dark brown, slaty, fossiliferous clays, Black Bluff fossils.....80 feet
25. Dark blue or black, sandy clays, with indurated bands, calcareous below, passing into an argillaceous limestone 16 to 18 feet, with phosphatized shell casts (Ripley) .....55 feet
26. Argillaceous limestone, with hard ledges, holding many shells (*Ostrea, Exogyra, Gryphæa,*) (Rotten Limestone).....1,000 feet
27. Hard, calcareous sands, highly fossiliferous, 6 to 8 feet; thin, yellow, cross-bedded sands, 15 feet; and below this a phosphatic greensand, 8 to 10 feet .....about 25 feet
28. Cross-bedded, glauconitic sands with thin clay partings, yellowish color prevailing .....40 feet
29. Dark gray, laminated, sandy clays, alternating with bluish sands.....15 to 20 feet
30. Laminated sands and clays, alternating with cross-bedded sands .....40 (?) feet
31. Compact, micaceous sands, cross-bedded sands, laminated clays in many alternations, including two small beds of pebbles und thin bed of lignitic matter .....60 (?) feet
32. Purple and mottled clays, 10 feet, with 15 feet of yellow, micaceous sands below.....25 feet
33. Purple and mottled clays, 10 feet, with 10 feet light yellow, coarse, cross-bedded pebbly (chert) sands.....20 feet
34. Purple and mottled clays.....10 feet
35. Purple and mottled clays.....10 feet
36. Dark gray, laminated clays, sandy partings, 25 feet, and gray sand, indurated, 15 feet, at Venable's and near Saunder's Ferry .....40 feet
37. Sandy clays, with leaf impressions, black scales like graphite fragments of lignitized stems.

COLUMN 2. *Alabama River.*

1. *Vicksburg.* White Limestone, with *Orbitoides Mantelli*; hill back of Claiborne, also back from river, from Marshall's Landing to Gainestown.....at least 140 feet
2. *Jackson.* Argillaceous White Limestone, with bones of *Zeuglodon Cetoides*, phosphatic nodules, and marls, from Claiborne to Marshall's Landing. ..... 60 feet
3. Scutella bed, followed by coarse, ferruginous sands, of which 17 feet is highly fossiliferous; hard, sandy ledge at base...30 feet
4. Calcareous clay, alternating with greensand containing *Ostrea sellaformis*..... 25 feet..

5. Light gray, calcareous sands, traversed by hard, sandy ledges, clayey in part, *Ostrea sellæformis* characteristic greensand, and shells at base ..... 35 feet
6. Blue clay, passing into greensand, upper half with fossils, lower half highly fossiliferous ..... 22 feet
7. Calcareous, clayey sands ..... 9 feet
8. Coarse ferruginous marl 3 feet followed by 20 feet of light yellow sands, few fossils ..... 23 feet
9. Bluish jointed clay ..... 12 feet
10. Light colored, aluminous sandstones, claystones, and silicious sandstones ..... 75 feet
11. Reddish, cross-bedded sands, 2 feet lignite at base ..... 22 feet
12. Laminated, sandy clays, gray color ..... 15 feet
13. Yellow sands, passing below into gray, laminated, sandy clay ..... 25 feet
14. Greensand marl, Bell's Landing ..... 10 feet
15. Gray, laminated, sandy clays 22 to 23 feet, passing into clay marl, Gregg's Landing, 5 feet ..... 30 feet
16. Sandy clays of prevailing gray color, varying in degree of sandstone and coarseness of lamination, 1 foot greensand marl at base ..... 50 feet
17. Gray, sandy clays ..... 10 feet
18. Gray, sandy clays, alternately thin, laminated, and heavy bedded; indurated by glauconitic clay on top and greensand bed in middle ..... 37 feet
19. Glauconitic sands, with *Gryphæa thirsæ*, indurated ledges passing through beds ..... 18 feet
20. White cross-bedded sands ..... 12 feet
21. Bluish, clayey, glauconitic sands, with *Gryphæa thirsæ*, several hard ledges ..... 50 feet
22. Glauconitic, clayey sands of varying degree of hardness, bed of lignite 4 feet (Coal Bluff) at base ..... 35 feet
23. Gray, sandy clays ..... 10 feet
24. Gray clay, cross-bedded sands, Burford's Landing ..... 10 feet
25. Gray, sandy clays, forming river banks from Walnut Bluff to Clifton ..... 35 (?) feet
26. Black, sandy clay marl, micaceous, Matthews's Landing ..... 20 feet
27. Black clay, Midway ..... 5 feet
28. Argillaceous White Limestone (*Nautilus Rock*) ..... 10 feet
29. Crystalline limestone (*Turritella*) back of Bridgeport.
30. Yellowish, micaceous sand (Ripley fossils) at Bridgeport and hills back of landing ..... 55 feet
31. Dark bluish gray, sandy, micaceous clays, weathering into yellowish shales, with indurated, sandy, projecting ledges at intervals of 5 to 10 feet throughout whole thickness, exposed at

Bridgeport, Tear Up Creek, Canton Landing, and hills back of Prairie Bluff and in Gee's Bend ..... 100 feet

32. Bluish, argillaceous limestone, with phosphatized shell casts, &c., Ripley formation ..... 30 to 35 feet
33. Sands of various colors, dark blue, gray to white, traversed by indurated bands of calcareous sands with Cretaceous shells ..... 60 feet
34. Highly argillaceous limestone, with ledges holding many shells, *Ostrea, Gryphæa, Exogyra,* ..... 1,000 feet
35. Hard, calcareous sands, with fossils strongly phosphatic in part ..... 20 feet
36. Alternating layers of horizontally laminated and cross-bedded, yellowish (glauconitic) sands ..... 40 feet
37. Laminated, blue clays ..... 10 feet
38. Blue, micaceous sands ..... 15 feet
39. Light colored micaceous sand ..... 20 feet
40. Laminated clays and blue sands, thickness not determined.

COLUMN 3. *Chattahoochee River.*

1. Light green, highly micaceous sand, resembles weathered schist, and but for the occasional water worn quartz pebbles might be mistaken for schist ..... 3 feet
2. Hard clay stained by ferruginous matter, breaks with conchoidal fracture ..... 1 foot
3. Hard white coarse grained sand held together by white clay, 15 feet
4. Red and gray variegated sandy clays (typical Tuscaloosa), shows at water's edge mouth of Bull Creek, Ga.
5. Strongly cross-bedded coarse sand and pebbles with some few fragments of schist and just enough white clay to hold the mass together. The quartzose pebbles are all well water worn while the softer bits of schist are but slightly abraded. This stratum varies in color from white to lemon yellow and in places green, while the upper part becomes mottled purple and yellow variegated. This last phase is most strongly developed at Thomas's Bluff, Ga., due east of Fort Mitchell, Ala. *Top of Tuscaloosa Series* ..... 40 feet
6. Dark gray calcareous sand, pyritous and containing nodular masses 6-12 inches in diameter with calcite nuclei. These nodules are arranged in strata about two feet apart, and terminate in an indurated stratum about 12 inches thick. Small fragments of lignite are scattered about through this stratum, and one or two large masses filled with calcitized teredos were found. The only other fossils seen were an *anomia* and an *exogyra* probably the young of *E. costata*, Say. The fossils are

all poorly preserved. Dip at this point 40 feet to the mile southward ..... 15 feet

7. Gray sand of the same nature as the preceding, only no nodules were seen, and the shells increase in quantity particularly in the lower part. The upper part of this stratum becomes more argillaceous and contains no fossils. Causes landslides in the banks like the Black Bluff clays, which they resemble somewhat physically. These sandy clays give rise to Uchee shoals, 100 feet
8. Laminated dark gray clays with masses of yellow sand distributed at irregular intervals throughout the stratum, best developed just above Uchee Creek, Ala ..... 25 feet
9. Yellow and white sands with thin seams of lignitic sand and an occasional "bunch" of gray laminated clay. These sands are exposed in a bluff about 100 yards from the river just south of Rooney's Mill Creek, Ga..... 50 feet
10. Quartzose conglomerate much like that at Havana, Hale county, Ala.; forms the shoal at Beden's Rock and the bluff at Hatchers's Lower Landing; merges gradually into a yellow sand, 50 feet
11. Yellow sands and gray clay containing bits of leaves. This stratum and the following are seen at Chimney Bluff, Ga.... 60 feet
12. Light yellow and white sands containing beds of well rounded quartzose pebbles sometimes 20 feet thick. Lignitized logs seen protruding from the bluffs. The sands contain a small *exogyra* at rare intervals. *The supposed top of the Eutaw Group* 45 feet
13. Gray sandy calcareous clay with lines of bowlder-like concretions projecting from the bank. First seen at Dawson's Woodyard, Ga. Few fossils occur in the lower part of this stratum except *Exogyra costata*, Say; a mile above Blufftown, Ga., characteristic Ripley shells mainly bivalves, are found in a much decomposed state throughout the stratum 6–8 feet thick. The uppermost 10 feet of the stratum are very fossiliferous. The river washes out little cave-like recesses in the banks. Near Jernigan's Landing, Ala., slight rolls in the strata are seen involving about 20 feet of the sands, these minature anticlinals and synclinals continue to within two miles of Florence, Ga.; the dip estimated from the lines of bowlders, averaging about 20 feet to the mile and is about normal in direction.... 120 feet
14. Two miles above Florence, Ga., and making part of a bluff 50 feet high at that place is a gray sand interlaminated with thin seams of a more argillaceous sand, all of which is unfossiliferous. Dip here about 40 feet to the mile..... 26 feet
15. Gray calcareous sands containing a small fragile *anomia* and a line of hard, rounded concretionary bowlders..... 40 feet
16. Gray and yellow sands, resembling in physical character those

of the Tertiary at Lower Peach Tree, Ala.....30 feet

17. Gray highly fossiliferous marl. The fossils are nearly if not quite all bivalves, and are mostly comminuted as if they formed an ancient shore line. There are numerous sharks' teeth, a hard black substance in sections resembling the under shell of a turtle, black coprolitic pebbles? and fragments of lignite...3 feet
18. Sandy stratum, indurated, and containing *ostrea sp?*.....1 foot
19. Cross-bedded gray sands and clay.....15 seet
20. Fossiliferous marl about the same in general character as 17, only little or no lignite was seen the marl appearing to be somewhat glauconitic. (The strata from 17 to 20, inclusive form a bluff on the east bank five miles below Florence, Ga).....2 feet
21. Gray, glauconitic, calcarerous sand weathering into fucoidal masses and containing a few soft white phosphatic nodules.....10 feet
22. Gray fossiliferous marl, shells much decomposed. An occasional lignitized log and numerous slightly phosphatic nodular masses containing fossils occur in this stratum.....5 feet
23. About the same in general character as 21, but contains indurated ledges about a foot thick which show the dip to average 40 feet to the mile, with numerous rolls. Ends just above the mouth of Cowikee Creek, Ala.....170 feet
24. Soft, less coherent sand, gray in color, appears at the mouth of Cowikee Creek, Ala., from which the south bank of the creek composed of this stratum, may be seen to rise 50 feet from the water.....60 feet
25. Gray calcareous sand, with indurated ledges, *Exogyra costata* Say. *Gryphæa vesicularis*, Lam. *Hamulus onyx Plicatula urticosa*, *Anomia* ? Forms the shoal at Frances' bar, and bluff at Eufaula, Ala.....190 feet
26. Light gray and yellow sands interlaminated with sand darker in color, more argillaceous and containing bits of lignitized leaves and twigs, no other fossils seen. Crops out in the gullies of Eufaula next below the Lafayette.....20 feet
27. A massive gray sand with a few fragile fossils and bowlders. This sand is only slightly calcareous and is more or less lignitic. Dip hereabout 100 feet to the mile.....40 feet
28. A more calcareous sand filled with *Exogyra costata*, Say, and many indurated ledges, giving rise to the first bar below Eufaula.....70 feet
29. Light yellow cross-bedded sands inclosed between indurated ledges.....20 feet
30. Calcareous gray sands with bowlders.....50 feet
31. Yellow sands and indurated ledges filled with casts, *Exogyra costata* Say, and *echinoids* set fast in the ledge. The sands are cross-bedded and contain some lignitic streaks.....35 feet

82. Gray fossiliferous sands with bowlders; the sand is massive and is fossil bearing only in the lowest 5 feet.....40 feet
83. Brown, laminated, argillaceous sand, disappears at the mouth of Pataula Creek, Ga.....5 feet
84. Light yellow sand interstratified very irregularly with a gray micaceous sand filled with friable Ripley fossils. Mouth of Pataula Creek Ga.....30 feet
85. Hard sandy ledge, weathered surface jagged, contains *Exogyra costata*, Say. and *echinoids*, very light yellow in color, white when dry and unweathered.....30 feet
86. Gray sand with indurated ledges, no fossils seen; merges gradually in the upper part into a dark almost black sand containing large nodular masses and interstratified with light yellow sands.....35 feet
87. White coarse conglomerate, the matrix material being calcareous. The quartzose pebbles decrease in size toward the top and the stratum becomes more argillaceous, there are many casts but all too obscure for identification.....18 feet
88. Massive blue clay, contains a few bits of teredo-eaten lignite (*Probably the top of the Cretaceous*).....6 feet
89. Massive sandstone coarse grained and almost a conglomerate.....8 feet
40. Light yellow silicious limestone containing large *Ostrea* and numerous obscure casts; nine miles above Ft. Gaines, Ga..10 feet
41. White calcareous sand containing a few obscure casts and *Ostrea*. The sand sometimes becomes irregularly indurated, and is the source of numbers of small lime springs. Forms the lowest part of the bluff at Ft. Gaines, Ga., and its uppermost 10 feet contains pockets of white sand inclosed by black clay, the clay resting in "pot holes" in the limestone. Estimated at..200 feet

Nos. 39, 40 and 41 represent our Clayton Division.

42. Glauconitic sand filled with *Gryphæa thirsæ*, Gabb. *Venericardia planicosta* and *Crassatella tumidula*.....8 to 12 feet
43. Gray, calcareous sandy clay, containing bowlders of clay and a few decomposed *Gr. thirsæ*.....15 feet
44. White and lignitic cross-bedded sands, and sandy gray clay containing one or two ledges of pseudo-buhrstone.....50 feet
45. Dark gray argillaceous sand with few fossils and fragments of water worn clay balls. The lower part becomes more fossiliferous, containing *Osteodes caulifera*, *V. planicosta*, and *Gr. thirsæ*.....6 feet
46. Greenish gray fine grained calcareous sand, very firm and holding decomposed shells mainly bivalves.....6 feet
47. Coarse glauconitic sand filled with large *Ostrea compressirostra*,

Ven. planicosta, and small *pecten* resembling the species occurring at Yellow Bluff on the Alabama..... 3 feet

48. Cross-bedded sands, yellow, the bedding planes being marked by streaks of gray clay.....10 feet
49. Yellow and gray sandy clays containing occasional beds of *O compressirostra*, and *Gr. thirsæ*. The indurated ledges which sometime occur (but seldom over two feet thick) are of the nature of "pseudo-buhrstone" and are filled with bivalves, the only exception noted being *T. Mortoni* (large). This disappears below the surface at the mouth of the first large creek flowing from the Ceorgie side below Ft. Gaines.....75 feet

Nos. 42 to 49 inclusive are assigned to the Nanafalia series.

50. Light yellow and gray sandy clays containing in the sandier portion, bowlders much like those seen at Bell's Landing. No fossils seen. These are undoubtedly the lower Peach Tree clays and sand (*Tuscahoma*). They become more sandy on ascending.....170 feet
51. Light greenish yellow sand filled with bits of decomposed shells and large *O. compressirostra* and *Ven. planicosta*.....3 feet
52. Gray sand filled with decomposed fossils. An irregular indurated ledge, (non-fossiliferous) occurs in this stratum. This is probably Wood's Bluff, though the only fossils that could be determined with any degree of accuracy is the small oyster so common at the typical locality .....18 feet
53. Blue, slightly sandy clay..... 6 feet
54. Light yellow silicious, (sandy) limestone filled with casts and containing pockets of *O. compressirostra*.....18 feet
55 Gray lignitic sandy clay (Hatchetigbee)..... 10 feet
56. Coarse white sand containing *O. divaricata* and a few other friable shells in the upper part.....12 feet

Nos. 51 to 56 inclusive represent the Wood's Bluff and Hatchetigbee series.

Buhrstone —The first flexures since leaving Eufaula, occur in this statum.

57. Plain buhrstone, rather sandy.....40 feet
58. Light yellowish green sand containing numbers of small *O. sellæformis*.....45 feet
59. Buhrstone, supposed summit of the series.....55 feet
60. Greenish yellow calcareous clay with a few decomposed fossils and an occasional large *O. sellæformis*.....12 feet
61. White sandy limestone, with *O. sellæformis*, in abundance, and pockets of large sized shells. Makes capping ledge to island at mouth of Omussee Creek, where the bluff is about 20 feet high.

This stratum is made up of alternate beds of hard and soft strata, all containing more or less *O. sellæformis*. The harder strata weather out into root like shapes and are sometimes rather argilleceous. Many return dips occur in this stratum stringing it along the banks for many miles further than it would be normally. The dips are all steep both ways and many gaps in the succession are caused by the washing out of the soft strata. Owing to these gaps and return dips it is rather hard to estimate the thickness of the statum with much accuracy. It dips below the surface of the river two miles below Gordon, Ala., and is last seen on the Georgia bank. At Gordon there is a very pronounced return dip, estimated at and not exceeding..... 60 feet

62. The "*Scutella* bed" weathers so as to make it not possible to count up its thickness. It is literally full of fossils mainly *Scutella Lyelli*, and *Pecten nuperus* with a few smaller and thicker *Scutella*. A bluff about 20 feet high occurs opposite the mouth of Sowhatchee Creek, Ga.....25 to 30 feet

Nos. 60, 61 and 62 represent the Claiborne.

63. White orbitoidal limestone, seen first at Dougherty's Wood Yard, Ga., on the Alabama side, 9 miles by the river from Neal's Landing, Fla. This limestone contains numerous *echinoids* about 5 miles above Neal's. The limestone continues as far as Miriam's Landing at which place the thickness is.....200 feet

No. 63 is the St. Stephens or White Limestone.

64. Argillaceous and sandy limestone, alternating with strata of purer character. Contains a *pecten* and an *ostrea* very close to our recent *Virginica*. This may be termed the *Chattahoochee group* as it is well developed at the Landing of that name, and in the eastern river bank for the next ten miles..... 35 feet
65. Light yellow sand containing pockets of fossils. Where there are no shells the sand is very calcareous. Fossils resemble those described by Conrad as Miocene from York Co., Va., and Maryland.....35 feet
66. Gray sand slightly calcareous..... 5 feet
67. Gray calcareous sand filled with shells. The leading fossil is a *mactra*.....10 to 15 feet
68. Black lignitic sand. This contains much pyrite sand from the efflorescence of ferrous sulphate arises the name Alum Bluff. Varies with the preceding.....10 to 15 feet.

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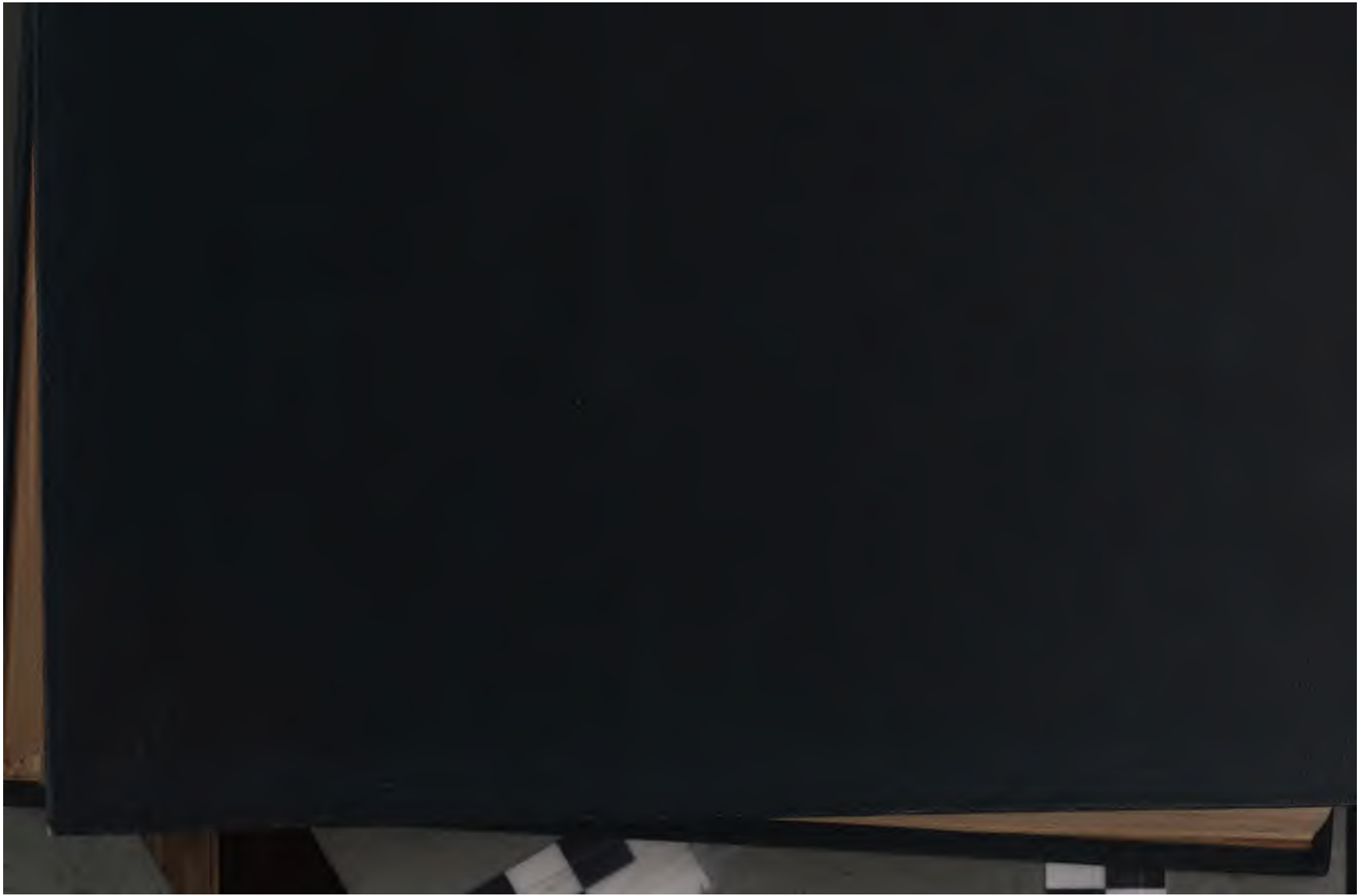
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